A HANDBOOK ON
DIABETES MELLITUS
AND ITS MODERN TREATMENT

By

J. P. BOSE, M.B. (Cal.), F.C.S. (Lond.)

IN CHARGE, DIABETES RESEARCH, CALCUTTA SCHOOL OF TROPICAL MEDICINE; PHYSICIAN IN CHARGE OF DIABETES DEPARTMENT, CARMICHAEL HOSPITAL FOR TROPICAL DISEASES, CALCUTTA

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To
MY PARENTS

PREFACE TO THE FOURTH EDITION

This volume gives in brief facts and figures which I have gathered during the last 28 years i e since I had initiated and organised in 1922 a new department in the School of Tropical Medicine for research and investigation in diabetes with particular reference to its special problems relating to India where diabetes is extremely common and the mortality particularly among the rich and the intellectual classes very high

As in the previous editions my aim has been to bring the most up-to-date useful and practical information regarding the disease before the busy practitioner and the medical students Endeavour has been made to present the whole subject to the reader in a systematic and practical manner giving particular attention to facts affecting Indian conditions and Indian ways of life This specially applies to the Diet section which has been completely overhauled enlarged and partly rewritten The author's system of dieting has also been remodelled and new scales of dieting suitable for vegetarians and non vegetarians both Indian and European have been incorporated The food tables in the book have been brought up to-date involving much thought and labour

The book has been thoroughly revised and re arranged and in view of the new work done within recent years many of the old data have given place to new ones This has meant substantial changes in some of the chapters and some of them had to be entirely re written

Emphasis is once more laid upon the opinion held by the author that with the advance in the knowledge and the treatment of the disease there is no reason why the diabetics of to-day should not live as long or as comfortably as their fellow non diabetics provided they are honest and willing to carry out the treatment faithfully

Since the discovery of Insulin it may be said that at least *four outstanding achievements stand out in bold relief* viz —(1) lengthening of diabetic lives and their increased efficiency (2) the ease and safety with which surgical operations can be performed (3) the possibility and safety of pregnancy in diabetic women and (4) the practical elimination of diabetic coma

If the present edition of the book proves as useful and *successful as its predecessors in achieving the aim and object* of the author namely to spread the most recent knowledge of the disease among all those concerned the author will consider his labours amply recompensed

J P B

The Sanctuary
41 4A Bagh Bazar Street
Calcutta April 1949

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CHAPTER I

History and Progressive Knowledge of the Disease

The history of diabetes can be traced back to the time of Moses In Papyrus Ebers an old Egyptian medical compilation there is mention of a disease called polyuria which in all respects appears to resemble diabetes closely

Among the ancient Greek writers the first mention of this disease is to be found in the writings of Aretæus of Cappadocia (*Circa*, A D 150) This eminent physician is believed to have been a contemporary of Galen and in the description of the disease he lays particular stress on polyuria and thirst The important point that the urine of diabetics contains sugar appears to have escaped the notice of all early European writers But if we refer to the old Hindu medical literature we find that this important clinical factor is mentioned in the Charaka Samhita a compendium made by the renowned Hindu physician *Charaka* (2nd century A D) It appears that *Charaka* collected his materials from a much earlier work of *Agnivesa*, who again based his writings upon the teachings of his master *Atreya* (6th century B C) *Susruta* (A D 500) gave a recognizable description of diabetes mellitus as *Madhu Meha* (or *Ikhu Meha*) or Honey urine and described the symptoms of thirst foul breath voracious appetite and langour

Among the European writers Thomas Willis an English physician of repute first noted the characteristic sweet taste of diabetic urine in 1670 thus establishing the basic principle for diagnosis between Diabetes Mellitus (diabetes with sweet urine) and Diabetes Insipidus the insipid form (with insipid urine) The real cause for this sweetness however was not recognized till a century after

wards (1776) when another English physician Mathew Dobson of Liverpool demonstrated the presence of sugar in diabetic urine by fermentation and other tests

The first hint that the pancreas is necessary for the complete utilization *of carbohydrate food in animals dates as far* back as 1682 In that year Johann Conrad Brunner of Switzerland excised the pancreas of a dog and found that the animal developed extreme thirst hunger and polyuria Brunner s experiment appears to be a pioneer one from the point of view of the internal secretion therapy though the exact significance of the very important results obtained was *not at all recognized by the author himself Brunner (who* may be remembered as having discovered Brunner s glands in the duodenum) with his friend Peyer (who helped him in the experiment and incidentally discovered lymph nodes in the intestinal mucosa) thought that the intestinal digestion was carried out by Brunner s glands and Peyer s patches and that the pancreas was of no importance The result was that *for more than a century and a half no one thought it worth* while to work on this line

The greatest advance from the point of view of research work on diabetes may be said to date back to the time of Claude Bernard (1813 78) a pupil of Francois Magendie (1783 1855) the pioneer of Experimental Physiology in *France* Our *knowledge of the functions of the liver and the pancreas will always be associated with the great name* of Claude Bernard This eminent physiologist had an inherently wonderful power of thinking physiologically Claude Bernard s attitude towards scientific investigation is best summed up in his own words which should be the proper attitude of every scientific worker Put off your imagination as you take off your overcoat when you enter *the laboratory but put it on again as you do your overcoat* when you leave the laboratory Before the experiment and between the whiles let your imagination wrap you round, put it right away from you during the experiment lest it hinders your observing power

Claude Bernard's famous discovery of the glycogenic function of the liver was arrived at somewhat accidentally by the finding of sugar in the hepatic vein of a dog fed on sugar A large number of ingenious experiments had to be undertaken before Claude Bernard finally established the glycogenic function of the liver on a permanent basis and succeeded in isolating glycogen

In 1849 Bernard made his most celebrated discovery that a puncture (piqûre) of the floor of the fourth ventricle of the brain in dogs produces temporary glycosuria In 1856 he proceeded to study the effect of the extirpation of the pancreas in order to see whether diabetic symptoms would thereby be produced His experiments however did not produce the desired result probably because the extirpation was not complete

Following Claude Bernard several other workers tried the same process but they did not come to any definite conclusion and it was left to Minkowski and Von Mering to make a memorable discovery which in fact may be considered as the foundation on which the work of subsequent investigators was built In 1889 they succeeded in producing acute and fatal diabetes in animals by complete extirpation of the pancreas

Long before the famous discovery of Minkowski and Von Mering Paul Langerhans (1869) an anatomist had described a peculiar group of cells in the pancreas which had since been known as the islands of Langerhans Kuhne and Lea a few years later showed that this group of cells received a very regular and abundant supply of blood In 1893 Laguesse and Diamare showed that the islet cells of the pancreas were distinct and separate from the secreting cells and occurred in the pancreas of all vertebrates In 1895 Sir F Sharpey Schafer suggested that diabetes might be caused through pathological changes in the islet cells of the pancreas It was Lepine however who definitely formulated the hypothesis that there was an internal secretion in

these islet cells which controlled the carbohydrate metabolism This was also suggested by Minkowski

Reference should also be made to the works of Lepine and Hedon in France and Hale White Rennie and Fraser in Great Britain all of whom prepared alcoholic extracts of the pancreas by different methods and administered them to diabetic animals but their researches in this direction did not meet with sufficient success to justify the administration of the pancreatic extract in the treatment of diabetes Zuelzer a German investigator was somewhat more successful in this line In 1908 he prepared an alcoholic extract of the pressed out juice of adult ox pancreas which when injected subcutaneously into animals removed the hyperglycæmia and glycosuria produced by the administration of adrenalin Encouraged by his success in animal experiments Zuelzer tried this extract on eight diabetic patients and in five of them decidedly favourable results were obtained The glycosuria became less acidosis decreased and the general condition of the patients improved and great hopes were entertained in 1908 that an anti diabetic hormone had at last been discovered Unfortunately however the extract prepared in this crude way gave rise to very marked toxic symptoms which overshadowed the beneficial action of the extract in such a way that further treatment by this method had to be given up This must be recognized as a brilliant piece of research work well begun and given up in haste and Zuelzer is entitled to credit for very nearly isolating insulin about twelve years before its actual discovery

In Great Britain Rennie and Fraser continued to work independently on these lines but the extracts prepared by them from the pancreas did not produce much beneficial effect on diabetic symptoms when given by the mouth In one case they tried the extract by subcutaneous injection *but though there was definite improvement in the general* condition of the patient the toxic reactions were so marked that further attempt had to be given up Like Zuelzer of

Germany they worked their way very near to the discovery of the elusive hormone but the repeated failures discouraged them from making any further attempts in the same direction

In 1909 McCallum ligated the pancreatic duct in a dog draining the tail third of the pancreas No glycosuria followed Seven months afterwards he excised the remaining two-thirds of the pancreas This was followed by mild glycosuria Three weeks later he removed the tail third which had begun to degenerate by that time due no doubt to the previous ligation of the duct This second operation resulted in severe and fatal diabetes

In 1912 Kirkbridge repeated McCallum s experiment and corroborated his results He definitely proved that the atrophied tissues resulting from the ligation of the pancreatic duct contained healthy islet tissues and it was only the acinous tissues of the pancreas which went to degeneration

In the same year Knowlton and Starling published the results of their experiments which showed that the power of utilizing sugar by a diabetic heart outside the body was markedly decreased in comparison with that of a normal heart under similar conditions Their conclusion was that in diabetes the tissues are unable to utilize carbohydrates properly By adding extract of pancreas in weak acid to the perfusion fluid they showed that the utilization of sugar by the diabetic heart could by that process be made to approach normal

Various investigators worked independently on this subject of preparing an active anti diabetic hormone free from toxic effects but the full credit for first publishing a practical method of preparation of insulin belongs to Dr F G Banting of Toronto A young orthopedic surgeon Banting had a great love and zeal for research work In November 1920 he conceived the idea of preparing an active extract from the atrophied pancreas brought about by the ligation of the pancreatic duct He argued that the

extract from the whole pancreas as used by other workers before him (without much success) must have contained proteolytic enzymes which had a destructive action on the hormone He thought that if he tied the pancreatic duct of a dog the entire pancreas would atrophy but the islands of Langerhans would be left intact He then proceeded to perform this experiment in collaboration with his friend Mr C H Best (who was only a second year medical student at the time) their efforts were crowned with great success and on July 27th 1921 a memorable day in the annals of research they had the satisfaction of finding that the extract which they had prepared from the atrophied pancreas (brought about by the ligation of the pancreatic duct) when injected subcutaneously or intravenously in diabetic dogs reduced both hyperglycaemia and glycosuria Thus 32 years after the epoch making discovery of Von Mering and Minkowski another similar discovery was made in the field of diabetes by Banting and Best The work was performed in the laboratory of Prof Macleod of Toronto who with the assistance of Prof Collip was of immense help in the subsequent preparation and the refining of the active principle to which the name Insulin was given

Permanent and world wide recognition of this great accomplishment in Medicine has been given by the award in 1922 of the Nobel Prize to Professors Macleod and Banting who with the finest spirit of fairness and professional generosity divided the award between themselves and their co workers Drs Best and Collip

CHAPTER I

Insulin and Its Later Modifications

Insulin is essential to the functioning and maintenance of life. All of us need insulin, the requisite amount of which is manufactured and regulated in our own system, i.e. in the pancreas.

In normal healthy individuals Nature regulates the supply of insulin with almost clock-work precision according to (1) the amount of carbohydrate consumed and (2) the amount of energy expended by physical labour, thus keeping a balance between production and expenditure. The three main factors which come into play in regulating the supply of insulin are: (1) amount of carbohydrate consumed, (2)) amount of glycogen stored and (3) depletion of the glycogen store by sudden demands made on it, e.g. physical exercise, etc.

The islands of Langerhans in the pancreas play an important part in the production of insulin. The weight of the pancreas in a normal healthy adult is about 66 grammes, the islands of Langerhans constituting about 3% of its total weight.

The normal human pancreas usually contains about 500,000 islets. Three types of cells are known to be present in these islets—the alpha, beta and D cells, so named by Bloom in 1931. Of these the beta cells are thought to be concerned with insulin production, though the evidence adduced in its support is yet inconclusive. The functions of the other two are still unknown.

The average insulin content of the normal human pancreas has been estimated at 1.7 units per gramme. The insulin content of diabetic pancreas is, however, very much less, sometimes coming down to 0.4 units per gramme or even lower. The total insulin production in a normal

healthy individual, with a daily intake of 400 grammes of carbohydrates and 2500 calories has been roughly calculated to be about 50 units per day.

The diabetic patients of the present day however are fortunate in that they can to a great extent overcome this handicap by availing themselves of artificial supplies of insulin. This was not possible before Banting's discovery in 1921. It appears to-day that given the proper facilities there is no reason why the diabetics of the present day should not live as long as his fellow non-diabetics provided they are intelligent, honest and willing enough to carry out the treatment prescribed for them.

Mode of preparation of insulin

Various modifications by different authorities have been introduced in the mode of preparation of insulin *since its discovery. It is not the object of this book to go into the details of these methods.* The first method em*ployed for its preparation was the extraction of the active* substance from normal ox pancreas using alcohol as a *means of preventing the enzyme action, a method originally* employed by Scott. Dudley made further modifications by precipitating the active material with picric acid and then converting the insoluble picrate into soluble hydrochloride by means of an alcoholic solution of hydrochloric acid. This hydrochloride is a whitish powder of which 0.5 to 1 mg will lower the blood sugar of a two-kilo rabbit to about 0.04 per cent and cause typical hypoglycæmic convulsions.

The method of preparation of Insulin as given in the *British Pharmacopœia* 1932 (Seventh Addendum 1945) is summarized below:—

The pancreas, which must be either fresh or kept frozen from the time of removal from the body, is finely minced. Alcohol (95 per cent.) is then added until the concentration of ethyl alcohol is about 60 per cent. v/v together with a sufficient quantity of Hydrochloric Acid to make the *reaction* of the mixture not less than *pH* 3.0 and not more than *pH* 3.5. The mixture is then filtered and the filtrate evaporated to small bulk, to which alcohol (95 per cent.) is added until *the concen*

trat on of ethyl alcohol is between 60 and 70 per cent V/V A preci pitate of inert matter is removed by filtration To the filtrate dehydrated alcohol is added until the concentration of ethyl alcohol is 95 per cent V V The precip tate so obtained is collected and dissolved in water The active material is separated from this solution either by adjusting the *reaction* of the solution to the iso-electric point (which lies between the limits corresponding to the values pH 5 and pH 6) or by adding Trinitrophenol The precipitate obtained in the former way is dried and powdered The precipitate obtained in the latter way is dissolved in a solvent containing 6 volumes of alcohol (80 per cent) to 1 volume of dilute Hydrochloric acid and 1 volume of distilled water This solution is poured into excess of Acetone and the resulting precipitate is *dried and powdered* *The necessary quantity of the dry powder is dis* solved in distilled water acidified to a *reaction* between limits corres ponding to the values pH 3 and pH 4 To the acidulated water used for dissolving the powder a sufficient proportion of some antiseptic to prevent the growth of any organism which may be accidentally introduced in the process of removing a portion of the contents of the con tainer is added The solution is sterilised by passage through a bacteria proof filter the potency is determined and the strength is adjusted It is then distributed into sterilised containers in which it is sealed

One pound of fresh beef pancreas contains on an average 2 800 to 3 100 units of insulin

Chemistry of insulin

Crystalline Insulin in a high degree of chemical purity was first prepared by Abel and Geiling in 1926 by the Brucine Pyridine Ammonium Acetate method and the crystals are described as being doubly refractive melting sharply at 233°C

Its empirical formula was described as $C_{45}H_{69}O_{14}N_{11}S + 3H_2O$ Its molecular weight was estimated to be about 35 000 and iso-electric point at pH 5 3 to 5 35 It is optically active and laevo rotatory

According to most observers Insulin is believed to be a complex protein derivative possibly of the nature of a proteose It gives positive Biuret Pauly Millon and Ninhydrin reactions It is composed of well known amino acids namely tyrosine 12 per cent cystine 12 per cent glu tamic acid 21 per cent leucine 30 per cent arginine 3

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quotient* has been found to take place under its influence It causes the disappearance or marked reduction of the hyperglycæmia as well as of the urinary sugar and the ketone bodies thus tending to restore the diabetic individual to normal condition

Thus we see that the total effect of a dose of insulin on blood sugar appears to depend on

(1) the glycogen content of the liver;

(2) the hydrogen ion concentration of the blood

As the pH of the blood decreases, there is an augmented glycogenolysis and hence the hypoglycæmic action of insulin is neutralized to some extent This is the reason why, in cases of diabetic acidosis, relatively large doses of insulin are required to reduce the blood sugar

Physical exercise taken during the period of insulin activity will greatly accelerate its hypoglycæmic effect This will be explained afterwards

Insulin hypoglycæmia

When a patient is given too large a dose of insulin the blood sugar falls below the normal level, producing a train of symptoms within 1 to 8 hours after the patient has received the injection

The symptoms of hypoglycæmia usually begin with a feeling of anxiety which the patient cannot account for The patient feels as if some trouble is impending There may be restlessness, tremulousness and even actual tremor, particularly of the extremities This is sometimes so marked as to make fine movements (such as writing threading a needle etc) impossible One of the most noticeable symptoms manifested at this stage is a great desire for food Dimness of vision sometimes diplopia or double vision

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* This term is used to indicate the ratio between the amount of carbon dioxide excreted in the expired air and the amount of oxygen consumed It is thus indicated as $CO_2 - O_2$ If glucose is completely oxidized into CO_2 and H_2O the respiratory quotient is 1 In diabetes the respiratory quotient is below 1 (about 0 7 or so)

may occur Vasomotor disturbance is quite common pallor of the skin alternating with flushing may be present and there may be profuse sweating which is sometimes a very characteristic symptom The pulse rate is sometimes markedly increased The severity of these symptoms increases with the degree of hypoglycæmia When the blood sugar level gets below 0 05 per cent very acute symptoms may develop The body temperature gets low the blood pressure falls the patient may get aphasic and the deep reflexes are lost Convulsions may take place with low muttering delirium and the patient may gradually pass into a comatose state

Causes of insulin hypoglycæmia—The various causes leading to hypoglycæmia may be summed up as follows —

(1) Too large a dose of insulin given in one injection brings on hypoglycæmia

(2) Administration of insulin too long before meals may result in hypoglycæmia

(3) Delay in digestion or failure in the absorption of food as in vomiting diarrhœa etc may produce hypoglycæmic symptoms

(4) Hard exercise taken immediately after insulin injection may cause hypoglycæmia

(5) In cases of complications (*e g*, infection coma etc) where large doses of insulin are required temporarily it may suddenly cause too much lowering of the blood sugar if the large doses are continued even after the subsidence of the main complications for which the large doses were given

Treatment of insulin hypoglycæmia—Fortunately all the serious symptoms of hypoglycæmia detailed above are amenable to prompt treatment If the patient is conscious the ingestion of carbohydrate in the form of 4 to 8 oz of orange juice or a tablespoonful of glucose relieves these symptoms within a quarter of an hour If the milder symptoms are not detected or given heed to and they are allowed to pass on to the coma stage 10 to 15 minims of sol

adrenalin chloride (1 in 1 000) given subcutaneously may gradually restore consciousness within 5 to 15 minutes Glucose can also be given by the mouth or intravenously A dose of pituitrin (1 c c) given subcutaneously also produces good results

If there is collapse keep the patient warm give hot coffee per rectum and also stimulants like camphor strychnine etc

Standardization of insulin dosage

The *physiological* unit* of insulin is that amount which on subcutaneous injection in a starved rabbit (not less than 1 kilogramme in weight) can lower the percentage of blood sugar to about 0 045 per cent within 3 to 4 hours and produce typical hypoglycæmic convulsions The international *clinical unitage however as adopted by the Health Section* of the League of Nations is one third of the above strength—three *clinical* units being thus equivalent to one *physiological* rabbit unit

The reason why 0 015 per cent was chosen as the percentage to which the sugar should become lowered in the standardization process is that at this level almost without fail the animal develops highly characteristic symptoms of hypoglycæmia consisting of violent convulsive seizures with intervals of coma These symptoms may finally terminate in death *which however can be prevented* by the subcutaneous or intravenous injection of dextrose (one gramme per kilo of body weight)

Keeping properties of insulin

When insulin came to India in the latter part of 1922 there was a great deal of controversy among different workers in regard to its potency and keeping qualities Some

* The International Standard amorphous insulin powder contains 8 units per milligramme It is dry soluble insulin kept in the National *Institute for Medical Research and the unit is the specific activity* contained in 0 125 mg of this standard preparation

people definitely asserted that insulin lost nearly all its potency owing to heat in the tropics The author worked on this problem for some time and the results of his investigation definitely showed that the alleged deterioration of insulin was more apparent than real and was really due to variations in the experimental animals *

It was found, for instance, that the albino Himalayan type of rabbits (which were generally used for the purpose of standardization of insulin out here) were very resistant to insulin action as compared to the brown Belgian hare type of rabbits (which were used in England and on the Continent for insulin standardization) In investigating the reason for the variability of insulin action in the two types of rabbits it was found by experiments that the adrenalin content of the albino Himalayan was high and as such was capable of inhibiting the action of insulin to a large extent This subject will be further dealt with in Chapter VII

Insulin has been found to keep fairly well if it is kept in a dry and cool place and if precautions are taken to prevent contamination during use

* The variability in rabbits used for the assay of insulin —Bose J P, and Acton H W, *Indian Medical Gazette*, Vol LIX, No 7, July, 1924

Europe the disease is said to be most prevalent in France especially in Normandy.

In India the disease is extremely common in Bengal specially among the rich and the educated classes. The cause appears to be a combination of ill-balanced diet, over-eating, sedentary habits, excessive intellectual work and too much mental worry inseparable from the present struggle for existence. The Bengalee Hindus appear to be more prone to get diabetes than any of the other races living in India.

The latest statistics collected by the author of 3,500 cases of diabetes give the following percentage of racial incidence of the disease —

	per cent
Hindus	47.3
Mohammedans	23.1
Europeans (including Anglo-Indians)	24.2
Other races	5.4

A very striking feature which becomes evident at once from the above statistics is that it appears to show a great preponderance of the disease among the Hindus as compared to the Mohammedans. As a matter of fact the incidence of the disease among the Mohammedans appears to be less even than among Europeans. This according to the author does not represent the actual state of affairs. The author is definitely of opinion that the apparent lower incidence of the disease among the Mohammedans is due in a great measure to the great reluctance on the part of the Mohammedan women to make their complaints known unless they are of such a nature as to cause much physical suffering.

Age of onset and sex incidence of diabetes

A classification of ... es

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CHAPTER III

Incidence of Diabetes and Mortality and Some of the Common Ætiological Factors

The usual definition of diabetes as given in the text books is far from satisfactory In old books we find it described as a condition of the body in which sugar appears in the urine But there may be many conditions other than diabetes in which one may pass abnormal amounts of sugar in the urine Diabetes mellitus again as the name indicates has been taken to mean an excessive flow of sweet urine This we also know cannot be a proper definition as it would then include many conditions like pituitary tumours renal glycosuria etc The urine of a normal pregnant woman is often excessive and there may be lactosuria but it certainly does not fall within the category of diabetes

Diabetes however may be defined as a constitutional disorder due to deficiency in the secretion of the islets of Langerhans in the pancreas resulting in a disturbance of the normal utilization and storage of carbohydrates as evidenced clinically among other factors by persistent hyperglycæmia with or without glycosuria

Racial incidence of diabetes

It has been stated by most observers that Jews are particularly liable to become diabetics it is perhaps their rich diet and sedentary habits more than any racial tendency which are responsible for the higher incidence of diabetes among them Diabetes is much more prevalent in America than in Europe as will appear from the mortality figures given later on Diabetes is said to be less common among the Chinese the Japanese and the Negros of Africa In

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A classification of the cases of diabetes that came under the author's observation arranged according to age groupings

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Europeans, Anglo-Indians and [illegible]	[illegible]
Other races	[illegible]

A very striking feature which becomes evident at once from the above statistics is that it appears to show a great preponderance of the disease among the Hindus as compared to the Mohammedans. As a matter of fact, the incidence of the disease among the Mohammedans appears to be less even than among Europeans. This according to the author does not represent the actual state of affairs. The author is definitely of opinion that the apparent lower incidence of the disease among the Mohammedans is due in a great measure to the great reluctance on the part of the Mohammedan women to make their complaints known unless they are of such a nature as to cause much physical suffering.

Age of onset and sex incidence of [illegible]

A classification of the cases of diabetes [illegible] under the author's observation, arranged accord[illegible] [illegible]

and sex gives the following percentage of incidence of the disease —

	Male	Female	Total
Children (up to 15 years)	0.35%	0.30%	0.65%
Young adolescents (16 to 25 yrs)	2.20%	1.20%	3.40%
Young adults (26 to 35 yrs)	9.40%	3.30%	12.70%
Middle aged (36 to 50 yrs)	37.60%	9.65%	47.25%
Old (51 yrs and upwards)	26.20%	9.80%	36.00%

It will be apparent from the above figures that the maximum incidence of diabetes occurs in the middle age (between 36 and 50 years) after which it declines again. *Joslin who collected data from 9803* cases has shown by detailed statistics that the maximum susceptibility to the development of diabetes *in males* occurs at age 51 and *in females* at age 55. In our figures we have shown that the middle aged persons constitute 47.25% of the diabetics in India.

The percentage incidence of diabetes amongst the children and young adolescents in India however shows comparatively lower figures.

Social position and profession

Diabetes in India is extremely common among the well to-do classes. This fact is also true to some extent in the *European countries as well. According to Von Noorden* the statistics of both London and Berlin show that the number of cases in the upper ten thousand exceeds that in the lower hundred thousand inhabitants.

What gout is to the nobility of England diabetes is to the aristocracy of India. The same cause *i e* chronic dietary excesses combined with indolent habits is mainly responsible for both. The difference in the nature of the diet is responsible for the presence of uric acid in the blood in one *case and the excess of sugar in the other*.

Among well-to-do educated Indians, specially merchants, lawyers, owners of landed properties, members of the Judicial service, etc., we get evidence of some of the causative factors of diabetes mentioned before, viz., sedentary habits, lack of physical exercise, ill-balanced diet, over-eating and over much mental work.

TABLE

Showing percentage incidence of diabetes classified according to profession and occupation

	Per cent
[illegible]	[illegible]
[illegible]	[illegible]
Landholders	[illegible]
Lawyers	[illegible]
Clerks	[illegible]
Physicians	[illegible]
Engineers	[illegible]
[illegible]	[illegible]
Teachers [illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	0
[illegible]	

Mortality

It appears from all records that diabetic mortality is increasing all over the civilized world. Prof. Joslin published a comprehensive statistical study of diabetic mortality in 1934 in which he stated that diabetes as a cause of death in the United States registration area had advanced from twenty-seventh in rank in 1900 to ninth in 1932. In England the death rate from diabetes in 1931 was nearly 30 per cent higher than in 1925, and 15 per cent higher than 1920. No explanation is forthcoming of the phenomenon.

In India the state of affairs appears to be the same. The statement of diabetic death rate in the registered area of

Calcutta and suburbs given below shows that the total death rate per 100 000 population has increased from 5 2 in 1929 to 25 9 in 1935 (the comparatively lower death rate in 1932 cannot be explained)

A partial explanation of this apparently increasing incidence of diabetes all over the world may possibly be due to the present day improved methods of diagnosis and also that both doctors and patients are more diabetes conscious now-a-days

Statement showing deaths from diabetes in the registered area of Calcutta and suburbs with their rates per 100 000 population

	Total Deaths	Death rate per 100 000
1929	57	5 2
1930	89	8 2
1931	103	8 0
1932	93	7 0
1933	1[illegible]5	10 4
1934	2[illegible]0	20 7
1935	300	25 9

What then is responsible for such increasing incidence of diabetic mortality in this country? The author is of opinion that this is to a great extent due to our rapidly changing mechanized civilization which while it tends to make the people more and more comfortable and ease-loving leads to sedentary habits The increasing consumption of sweets as well as of rich and luxury foods which appear to be inseparable from the menu of the rich and the leisured classes is another potent cause The greater stress and strain of modern high life appears to be a third cause

In the statement below diabetic mortality in some of the principal cities and countries of the world is given for comparison of the death rates

Ætiology of Diabetes

The consensus of the present day opinion is that pancreatic lesion plays the most important part in the ætiology of diabetes Allen notes that there is a very definite relation between the severity of the disease and the amount of pancreatic tissue left in the body He has shown by experiments on dogs that when only one tenth of the pancreas if left behind a severe type of diabetes invariably follows with a residue of one sixth of the gland a mild type of diabetes results with a residue of one fourth of the gland there is no spontaneous glycosuria but the carbohydrate tolerance is definitely diminished

It will also be evident from a review of literature on the subject that the manifestation of diabetes does not depend on the loss of or damage to the ordinary pancreatic acini but the root cause of this disease centres round the islands of Langerhans though the nature of the factor or factors giving rise to the diseased condition of the islet cells has not yet been clearly understood From the history of the literature it would also appear that the relationship between diabetes and the pancreas as also the fact that the internal secretory function of that organ has a great influence on the carbohydrate metabolism had been definitely determined by a number of observers before Von Mering and Minkowski established in 1889 the relation between the functions of the pancreas and experimental diabetes Allen s statement in regard to this point seems to be more logical though difficult to prove He observed that clinical diabetes arises regularly on the basis of antecedent pancreatitis and that it is now sufficiently established that the normal cause of diabetes is pancreatitis

It has been shown by experiments that hyalinization and atrophy of the islands of Langerhans are amongst the common pancreat[illegible] s in diabetes mellitus but the re[illegible] why the [illegible] should undergo specific degenera ti[illegible] not yet [illegible]rstood

We would now consider some of the predisposing causes of diabetes which directly or indirectly throw undue strain on the islet cells of the pancreas and cause their hyaline degeneration and atrophy sooner or later.

Obesity

The association of diabetes with obesity is quite a common finding in a large proportion of cases in India. In about 80 per cent. of the cases that came under the author's observation there was definite history of the disease first appearing while the patient was in an obese condition.

The author estimated the carbohydrate tolerance in a series of cases of obese Indians, quite normal in all respects except that they were 30 to 40 per cent. over weight in relation to age and height. *In about 40 per cent. of these cases* he found a definite decrease of tolerance, sometimes in quite a marked degree. This in the opinion of the author may be considered to be their pre-diabetic stage, and if these people were not careful, they were likely sooner or later to become victims of diabetes.

Lawrence in his book, 'Diabetic Life' goes so far as to say that 'to be normal or slightly under-weight is an insurance against diabetes'. Joslin considers diabetes to be a penalty to obesity; the greater the obesity, the more likely is Nature to enforce it. According to him, the most favourable weight for longevity in middle life is 10 to 20 lb. below the average weight (calculated from the table according to the age, sex and height of the individual). Even 20 lb. below the average weight is safer than the average weight itself.

Nature of food

Excessive ingestion of carbohydrate food has been attributed by many to be a cause of diabetes in India; but, according to the opinion of the author, it does not *by itself* act as a contributory factor. We find that some races, as

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Lawrence (1926) has definitely shown that exercise greatly increases the hypoglycæmic action of insulin Joslin has also observed that one of his patients could do without the evening dose of insulin the day he played golf The author holds the same view and thinks it very important that, *in patients undergoing insulin treatment, the dose of insulin should be adjusted according to the exercise prescribed for him*

The following experiment carried out by the author shows the effect of exercise in augmenting the insulin action in a moderate case of diabetes On the first day, after a preliminary blood sugar test, the patient received a dose of 12 units of insulin subcutaneously and the blood sugar was estimated every hour for the next three hours (Table A) Next day, under exactly similar conditions the patient was given the same dose of insulin but, in addition he was made to take active exercise with Sandow s grip dumb bells immediately after the insulin injection was given(Table B) Both the results, graphically shown in the following diagram (Chart II) show the difference at a glance It should be noted here that the patient experienced mild symptoms of hypoglycæmic shock on the second day of the experiment

TABLE A

Effect of insulin on the blood sugar level in a case of diabetes of moderate severity

	Per cent
Blod sugar before	0 208
(12 units of insulin given)	
Blood sugar 1 hour after	0 163
Blood sugar 2 hours after	0 136
Blood sugar 3 hours after	0 175

TABLE B

Effect of insulin combined with exercise on the blood sugar level of the same patient

	Per cent
Blood sugar before	0 210
(12 units of insulin given and exercise started)	
Blood sugar 1 hour after	0 132
Blood sugar 2 hours after	0 084
Blood sugar 3 hours after*	0 063

That exercise helps in the oxidation of carbohydrates in the muscles and thus promotes carbohydrate utilization of diabetic patients seems to be undoubted at present, in

* The [illegible] d hypoglycæmic symptoms

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Blod-sugar before	0 208
(12 units of insulin given)	
Blood sugar 1 hour after	0 168
Blood sugar 2 hours after	0 136
Blood sugar 3 hours after	0 125

TABLE B

Effect of insulin combined with exercise on the blood-sugar level of the same patient

	Per cent
Blood sugar before	0 210
(12 units of insulin given *and exercise started*)	
Blood sugar 1 hour after	0 132
Blood sugar 2 hours after	0 084
Blood-sugar 3 hours after*	0 063

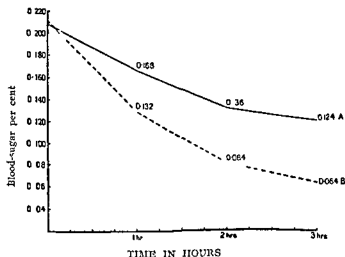
That exercise helps in the oxidation of carbohydrates in the muscles and thus promotes carbohydrate utilization of diabetic patients seems to be undoubted at present in

* The patient complained of mild hypoglycæmic symptoms

view of the work done on this line The work of Hill clearly shows that if a normal healthy individual takes physical exercise the respiratory quotient rises presumably because the carbohydrates are oxidized Allen has stated that his diabetic dogs with known limits of carbohydrate tolerance showed marked increase in tolerance on vigorous exercise and has demonstrated this fact by blood sugar and urine tests He has also shown that diabetic dogs which had glycosuria regularly on a daily ration of 100 gm of bread could remain perfectly sugar free with double the quantity of bread if they were regularly exercised The author has made observations of this nature in many of his cases and is definitely of opinion that the carbohydrate tolerance of diabetic patients improves under the stress of physical exercise

CHART II

The effect of exercise in augmenting the insulin action on the blood sugar in diabetics



The effect of exercise appears to be even more marked in cases of diabetic children. Their improvement is found to be steadier and quicker with exercise than without it.

Strenuous exercise should, however, be avoided in severe cases of diabetes lest it induces acidosis. It has been shown that strenuous exercise in a severe case lowers the respiratory quotient, probably because it breaks down a disproportionately large quantity of fat.

One cannot too strongly emphasize the importance of the value of physical exercise in diabetes, either as a prophylactic measure or as a form of treatment in mild and moderate cases. The very pithy remark made by a Harvard professor (one of Joslin's patients), namely, that mental work makes sugar but manual work breaks it up, seems to be very appropriate. The author is definitely of opinion that lack of physical exercise is one of the most important among the ætiological factors of diabetes, especially in this country. He has come across many cases where, by suddenly giving up regular or hard physical exercise and taking to sedentary work, especially those entailing increased mental labour, diabetes mellitus was brought on. Some of these people have the erroneous impression that the excessive amount of physical exercise previously undertaken by them was the cause of their trouble and it is sometimes difficult to convince them that to go back to their old habits is their best line of treatment.

It is noteworthy that in the old Hindu medical literature, this important ætiological factor is strongly emphasized and among the causative factors of the disease are mentioned lack of exercise and laziness.

Climate

It has been stated that tropical and sub-tropical climates lower the carbohydrate tolerance of individuals. Basset Smith* has stated that under the influence of the tropical

* *British Medical Journal*, 31st July, 1926.

heat there is a tendency to retain carbonic acid in the alveolar air while the people are at rest and also a predisposition particularly in the rich to glycosuria and acidosis

Dr D Zel Zion* working at Jerusalem Palestine has made the following interesting observations —

(1) That the sub tropical climate of Palestine in general and the hot tropical regions in particular cause a lowering of carbohydrate tolerance in the newly emigrated men and in many cases they manifest symptoms of diabetes

(2) That considerable improvement sometimes amounting to recovery results after leaving Palestine

(3) That the nature of the disease according to its response to insulin may be taken to be pancreatic diabetes

(4) That diabetes mellitus is comparatively more severe in the hot regions of Palestine than in the cooler and the mountainous regions

(5) That the course of the disease is more severe and complicated in summer than in winter

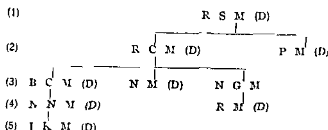
De Langen and Schut have found higher fasting blood sugar values in the white inhabitants of Java residing near the seashore but when the same individuals move to more elevated and cooler places the hyperglycaemia disappeared only to reappear again when they returned to the tropical coast

Heredity

It is usually believed that diabetes is a hereditary disease It is a curious fact in the history of most of these cases that obesity is also a hereditary factor There are many families in which diabetes can be traced to run back for three or more generations In one such family where both the father and the son were the author s patients and both belonged to the legal profession the disease could be traced back to the fifth generation On account of the very

* *Arch v fur Schiffs und Tropen Hygiene* October 1932

interesting nature of this finding the following family tree is appended (D) denotes diabetic



George Graham is of opinion that owing to family diathesis in these groups of cases the beta cells of the pancreas degenerate more readily Begg is of opinion that heredity is an important causative factor of diabetes and so are Kellogg and many others Dr Chunilal Bose has cited a large number of cases in support of this theory

Joslin has also collected a large number of statistics on this head but he hesitates to attach too much importance to heredity as a factor in the onset of the disease

The conception of the hereditary nature of diabetes appears to be an old one A description of its hereditary character is noted in an old Indian medical literature in the seventeenth century A D

Perhaps the true view on a consideration of these cases would be that diabetes should be looked upon as a familial *affection rather than as a hereditary disease We have no* positive proof that diabetes is transmitted from parents to children To make sure that diabetes is hereditary some of the younger members of a diabetic family should be removed from the environments and habits peculiar to the family and should be brought up amid scenes and surroundings and in ways of life which do not tend to produce the disease in a normal healthy individual Only in those circumstances could it be ascertained whether brought up differently the child of diabetic parents shows a greater propensity to become a diabetic subject What usually

ppens however is that children in diabetic families are ide to live in the same environments and subjected to same habits of life as the other affected members—the ne family habit of suralimentation sedentary life defec e hygiene and various other circumstances well known causative factors to start the disease

According to our present conception therefore a pre position to diabetes seems to be indicated as a mendelian essive characteristic and this influence is now considered be of primary importance although such predisposition iy not be revealed until late in life

This naturally brings up a very important question and it is with regard to advising young diabetics about rriage Though opinions somewhat differ on this point author s views regarding it may be summarized as lows —

1 A diabetic can marry a non-diabetic with no dia betic history in his or her family
2 A diabetic should avoid marrying a non-diabetic who has a clear diabetic history in his or her family
3 A diabetic should never marry another diabetic

Age

No age is exempt but the disease is far more common iong middle aged persons the mortality from the disease wever is much higher in young people than in older rsons The majority of cases which came under the ithor s observation were between the ages of 35 and 50 ars The youngest was an Indian boy 16 months old is was an acute case of diabetes and he had recovered from ma twice before coming to the author

In India it has been found that a few cases suffering om infantile cirrhosis of the liver suffer from glycosuria ut these should not be confused with true diabetes

Intemperance

It has been stated that alcoholism reduces the carbohydrate tolerance However, in our experience intemperance cannot be described as a cause of diabetes in India

Nervous origin

Excessive mental strain and emotion and constant worry have been found to bring about glycosuria and diabetes Sudden shock to the nervous system in the shape of deaths in the family severe loss in business etc, has certainly been found in a few cases to be the precipitating factor in causing diabetes specially of the acute type

In 1923 the author carried out an interesting experiment which showed how nervousness and worry could bring about temporary glycosuria He analysed the urine of some of the D T M students both before and after their *viva voce* examinations and was surprised to find that 5 per cent of the students had slight but unmistakable glycosuria following the ordeal

This temporary appearance of sugar was due probably to excitement or fright causing a marked sympathetic disturbance and the consequent outflow of an excess of adrenalin which liberated sugar from the glycogen storehouse of the liver, causing both hyperglycæmia and glycosuria The author while conducting certain experiments on the albino Himalayan rabbits (which are said to possess a very sensitive sympathetic system) incidentally got some very interesting results He found that when blood was drawn quietly without disturbing the animal the blood sugar was more or less constant but when the rabbits got excited, either through fright or other causes the blood sugar shot up to about 50 per cent higher and on two occasions it became nearly double This fact should be borne in mind by physicians securing samples of blood for sugar tests

Among other ætiological factors of direct or indir origin may be mentioned shock of any kind injur specially of the head and spine brain tumours and co lesions in the medulla either due to invasion by new grow or sclerosis

Insanity and glycosuria

It is stated that 10 per cent of insane persons pass su in their urine Henry Devine (*Recent Advances in Psychia* 1930) states that it is a common experience in the investi tions of mental disorders to find the presence of glycosu thus revealing a tendency in such cases to faulty car hydrate metabolism Drury and Farran Ridge find a turbance of sugar metabolism in each type of mental order investigated the most striking being observed melancholia and confusional states In the records of in patients of the Ranchi European Mental Hospital (c municated to the author in 1927) it was found that 7 patie out of 73 (i e 9 56 per cent) had glycosuria The reco are too incomplete to explain this fact but they sug interesting possibilities Out of the 7 cases of glycos among the female mental cases there were two cases dementia præcox two of paranoia two of manic depres and one of secondary dementia

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Syphilis

The relation of syphilis to diabetes has not been very well worked out though there are cases in which diabetes has been attributed to syphilitic infection either by directly setting up pancreatitis or indirectly by interfering with the blood supply of the pancreas due to arteriosclerosis How

ever, it cannot be considered as a causative factor of diabetes Joslin states that only 16 out of his 1 000 cases (1 6 per cent) gave a positive Wassermann reaction The author s record shows 2 5 per cent

Infection

Severe infection of any kind may prove to be a direct cause of diabetes probably owing to some kind of damaging effect on the pancreas by the toxin Lawrence and Buckley have shown by experiments that diphtheria toxin will practically annihilate the action of insulin One case that came under the author s observation a lad of 14 had an acute onset of diabetes after cholera Another a young man of 26 had acute diabetes with grave acidosis after a severe Shiga infection

It has been shown by Charin and Carnot that a dog may be rendered diabetic by injecting bacterial cultures into the pancreatic duct (*B coli B pyocyaneous, Streptococcus* etc)

There seems to be little doubt however that in a diabetic patient infection of any kind definitely lowers his carbohydrate tolerance and visibly increases the severity of the disease though temporarily The association of an infection usually of a severe nature e g lobar pneumonia with the onset of acidosis and even of coma has been noticed in a considerable number of cases

Asphyxia

Poisoning with coal gas carbon monoxide carbonic acid gas chloroform ether etc has been known to bring about hyperglycæmia and even glycosuria Mention may be made of a very interesting case of acute diabetes which came under the author s observation The patient, a young man of 22 was a mining engineer and had at one time to work in a pit for more than 20 hours When he came out he complained of headache and severe thirst The

author remembers that when he came to the laboratory, he had with him an earthenware pitcher full of water and a few cocoa nuts to satisfy his thirst He had severe polyuria and complained of a burning sensation in the whole body His urine on analysis showed 10 per cent sugar with marked reactions of acetone and diacetic acid His blood sugar was 0 3 per cent

The spectroscopic analysis of his blood showed two well marked bands of carboxyhæmoglobin The patient had severe acidosis and died in coma in a few days This was before insulin had come into use

Trauma

Ordinary trauma cannot be considered as an ætiological factor of diabetes, but as stated before injuries to the head and spine may bring about diabetes

Internal secretions

It has amply been demonstrated that diabetes is caused through defect in the hormone producing capacity of the pancreatic islets Successful extirpation of the pancreas has been found to produce diabetes in experimental animals and conversely the pancreatic hormone (insulin) corrects the abnormalities in human diabetic subjects

Modern researches have further shown that though the insufficiency of the pancreatic hormone might be the basic cause of abnormality in diabetic mellitus, there are other extra insular factor or factors influencing the causation of the diabetic state For instance, it has been found that the pituitary gland has got a profound influence on carbo hydrate metabolism Young in 1937 produced experimental diabetes in animals by repeated injections of Ant pituitary extract As a matter of fact, the consensus of opinion amongst the present day workers is that the anterior lobe of the pituitary gland secretes a hormone which is contra

insular i.e. it opposes insulin action and hence elevates the blood sugar level. This hormone is secreted in the cerebro-spinal fluid exerting thereby a direct action on the sugar centre of the brain stem.

It is also well known that acceleration of the internal secretions of the thyroid and the suprarenal glands may produce hyperglycæmia and glycosuria whereas defective secretions are followed by increased tolerance for carbohydrates. Glycosuria in Graves disease is a fairly common occurrence. Injections of adrenalin produce hyperglycæmia and often glycosuria and in the early state of acromegaly glycosuria is often noticed. On the other hand some cases of myxœdema, Addison's disease (last stage) and adiposis dolorosa show unmistakable signs of increased tolerance for carbohydrates.

Alloxan Diabetes *

That Alloxan would induce diabetes mellitus in experimental animals was found by Jacob in 1937 who showed that the intravenous injection of Alloxan in fasting rabbits produced hyperglycæmia. Since then various workers like Bailey, McLetchie, Dunn and others worked on the same line and found that Alloxan had almost a specific degenerative action (partial or total) on the Beta cells of the islands of Langerhans.

The optimum diabetogenic dose of Alloxan varies with the animal used. With rabbits doses as small as 100 mg per kilo will usually produce diabetes.

Alloxan causes a transitory hyperglycæmia after injection in rabbits, lasting for about an hour due to excessive mobilization of glucose through stimulation of the adreno sympathetic system followed by profound hypoglycæmia within 2 to 8 hours after injection due presumably to an over stimulation of the islet cells and finally permanent

* Alloxan is the ureide of mesoxalic acid having a formula $C_4N_2H_2O_4$ and is chemically closely related to purines (uric acid).

hyperglycæmia in 24 to 36 hours due to necrosis of the islet cells of the pancreas

Alloxan has also been found to have some damaging effect on the suprarenal cortex anterior lobe of the pituitary and the liver The mechanism of the action of Alloxan in the production of experimental diabetes in animals has, however, not yet been clearly understood

CHAPTER IV

Carbohydrate Metabolism

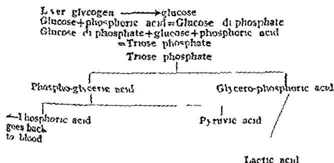
So far as our present knowledge goes the outstanding feature of diabetes is a decreased capacity of the system for the utilization of carbohydrates Normally the carbo hydrates are the great energy producers of the animal organism and by reason of the ease with which they undergo combustion they supply the greater portion of the energy requirements of the body It should be remembered that in diabetes though the sugar in the urine is chiefly derived from the non utilization of starch and sugar ingested a good portion of it may come specially in bad cases from proteins as well Diabetes is a metabolic disorder in which the proper utilization of all the three food principles—carbohydrates proteins and fats—does not take place The carbo hydrates in the food undergo a series of changes during the process of digestion and are eventually absorbed directly into the portal capillaries principally as glucose and in small amounts as levulose and galactose

The assimilable polysaccharides (such as starch glycogen lactose sucrose and maltose etc) are all rapidly hydrolysed by the various digestive enzymes into their constituent monosaccharides which are then absorbed into the portal circulation Unhydrolysed polysaccharides such as cellulose and pentose are not absorbed in any appreciable quantity from the alimentary canals of normal animals The monosaccharides such as glucose are absorbed as such without hydrolysis It was believed at one time that all sugars were converted into glucose in the course of their passage from the intestines to the portal circulation It is *known now that monosaccharides* of all kinds are absorbed into the blood stream as such and are only converted into glucose after they have reached the liver

The portal vein thus conveys a stream of sugars t liver where, by a process of dehydration they are conv into glycogen, which is, again, whenever necessary, r verted into dextrose for the purpose of physiological o tion in the tissues The liver thus serves a double func (1) as the store house for the sugar absorbed from the i tines and (2) it provides a means for the regulated re of the dextrose, helping, to a great extent, to mainta proper sugar balance in the system

Unlike liver glycogen however the glycogen form the muscles (from the excess of glucose in the blood) ap to be irreversible, because once the absorbed glucose is verted into muscle glycogen, it is retained there until up (mainly into lactic acid) by muscular activities

There is plenty of evidence in the literature of existence of a close relationship between the carbohy metabolism and inorganic phosphates of the blood It been observed by the author,* for instance that during stage of active carbohydrate metabolism, there is a re of the inorganic phosphates from the blood which com with the sugar to form a compound (hexose phosphate which intermediary stage glucose is known to be fi utilized in the system According to Meyerhof the ge scheme of carbohydrate metabolism appears to follow following path —

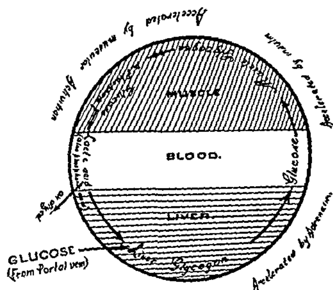


* Relation of inorganic phosphates to carbohydrate metabol Bose and De *Indian Journal of Medical Research* Vol 28 January

It will thus be evident from the above that the glycogen in the muscles combines with phosphoric acid to form glucose di phosphate which undergoes a few intermediary changes before it finally breaks down into lactic acid and phosphoric acid. Part of the lactic acid thus formed (about three fourths) is carried to the liver and is rebuilt into glycogen, while the rest (the remaining one fourth) is oxidized in the system and furnishes the necessary energy The breaking up of the muscle glycogen into the final products of lactic acid accompanies muscular activities

Thus there exists between the liver glycogen, blood sugar and the muscle glycogen a continuous interchange governed in accordance with the resources and the physiological needs of the organism This is shown by the diagrammatic representation given below

Cyclic representation of the mechanism of glucose utilization in the system



Although as stated before, the muscle glycogen cannot serve as a direct source of the blood sugar (like the liver

glycogen), it may, after having been broken up into lactic acid and rebuilt into liver glycogen, help to replenish the blood sugar indirectly

Metabolism in diabetes

(1) *Carbohydrates* —The main defect in the carbohydrate metabolism in diabetes can be classified under the following two heads —

(*a*) The liver loses the power of converting glucose into glycogen and storing it as such and thus the excess of the glucose, which escapes through the liver, floods the blood stream and causes hyperglycæmia, when the hyperglycæmia thus produced crosses the "threshold limit glycosuria appears

(*b*) The pancreas loses the power of producing the requisite quantity of insulin and hence the tissues are unable to oxidize the excess of the sugar The result is that proper and efficient removal of the excess of sugar from the blood and the tissues does not take place and a condition of hyperglycæmia and hyperglycystia persists

(2) *Protein* —A good portion of the sugar in diabetic urine is said to be derived from protein foods We know that the protein molecules of the food are broken down into amino-acids, some of the amino acids, specially glycin alanin aspartic and glutaminic acids etc, are *glycogenetic,* i e, capable of producing glucose, while there are others which are *ketogenic,* i e, tend to produce ketone bodies in suitable subjects It is well known that in cases of severe diabetes, large amounts of sugar and ketone bodies are found in the urine on protein diet alone

(3) *Fat* —The combustion of fats in the system is closely allied to that of carbohydrates We know that fat needs the

fire of the burning sugar for its consumption When fats are thus completely oxidized the final products are CO_2 and H_2O but when incompletely oxidized owing to a defective carbohydrate furnace the fat begins to smoke as it were and highly acid intermediate products such as β oxybutyric acid aceto acetic acid etc are produced which *tend to produce ketosis* It is also known that glycerol resulting from the splitting up of fats may be partly converted into glucose thus indirectly causing an increase of glycosuria in diabetes

Influence of the nervous system and the ductless glands on sugar metabolism

Since Claude Bernard s famous discovery in 1849 viz *that the puncture of the floor of the fourth ventricle (in the* space between the roots of origin of the eighth and the tenth cranial nerves) is followed by hyperglycaemia and glycosuria it has been recognized that the control over the amount of sugar in the blood is in some way connected with the anatomical and physiological integrity of the nervous system Claude Bernard s important discovery was followed by vigorous research on the subject and it was found later on that the stimulation of the great splanchnic nerve gave similar results This led to the important *inference that there was a sugar regulating centre in the* medulla

It is generally held that the so called diabetic or glycogenic centre exercises its control over the liver through efferent impulses travelling along the spinal cord to the liver by the splanchnic nerves It has also been suggested *that the splanchnic nerves* contain secretory fibres which control the production of the glycogenolytic ferment by the hepatic cells thus regulating the rate at which glycogen is transformed into dextrose in the liver From the point of view of nervous control the suprarenal bodies are believed to play a prominent part in the transformation

of glycogen into sugar The adrenals are reflexly stimulated by the great splanchnic nerves and the epinephrin thus thrown into the circulation acts on the liver cells causing a conversion of glycogen back into sugar In support of the adrenalin theory it may be mentioned that when the adrenals are removed neither the puncture of the fourth ventricle (the so called diabetic centre) nor the stimulation of the splanchnic nerves give rise to glycosuria We thus see why temporary glycosuria might occur during emotional states and in nervous conditions

Increasing evidence is being obtained as to the important part which the Anterior Pituitary plays in sugar metabolism It has definitely been shown that hyperglycæmia polyuria and glycosuria can be produced within 24 hours *in healthy* adult dogs by injection of extracts of the anterior lobe of the pituitary body of the ox The mechanism of action is believed to be one of increasing glycogenolysis in the liver It would be of interest to mention here that the work of the author in connection with glycosuria in pregnancy*, as early as 1922 brought forward interesting evidence that the pituitary played a great part in producing this condition It has been observed that during pregnancy the anterior lobe of the pituitary shows enlargement with marked histological changes Glucose tolerance test has been applied to a number of cases of pregnancy showing intermittent glycosuria with interesting results The close correspondence between the curves obtained in these groups of cases and those obtained in cases of pituitary lesions with evidence of hyper pituitarism are very striking The suggestion which the author made was that the increased activity of the pituitary body during pregnancy caused changes in carbohydrate metabolism leading to temporary glycosuria

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* Glycosuria in pregnancy—Mackenzie Wallis and J P Bose *Journal of Obstetrics and Gynaecology of the British Empire* Vol 29 No 2 Summer 1922

It has been suggested that the anterior pituitary hormone is contra insular i e it opposes the action of insulin The recent experiments are lending strength to the theory of the existence of a hormone in the anterior pituitary which when in excess antagonizes the action of insulin

There are many instances in which glycosuria is associated with cerebral lesions We know that injuries to portions of the brain in the neighbourhood of the hypophysis more particularly in the hypothalamic region produce glycosuria Glycosuria is more frequent after injuries to the base of the skull and after cerebral hæmorrhage it is usually transitory in nature but may pass on to true diabetes All these glycosurias resemble that produced by the puncture of the floor of the fourth ventricle

CHAPTER V

Pathology and Morbid Anatomy

It has already been stated that diabetes is a disease associated with definite pathological basis in the pancreas specially in the islands of Langerhans Cawley in 1788 was the first to observe and report the case of a diabetic with marked pancreatic damage at autopsy thus suggesting for the first time the connection between pancreatic lesion and diabetes The importance of this discovery was how ever not properly recognized till a century afterwards when Minkowski and Von Mering established beyond doubt the relationship between the extirpation of pancreas and ex perimental diabetes

The work of Minkowski and Von Mering stimulated further investigation on this line and as a matter of fact opened a new field of research Minkowski also showed that if instead of removing the whole pancreas only one eighth of the gland was left behind no diabetes resulted This partly explained the thorny question raised by some workers who had found entire absence of diabetes in indivi duals whose pancreas at autopsy was found to be largely destroyed either by necrosis or by malignant growths On the other hand autopsy in many diabetic patients showing the presence of apparently healthy pancreas remained a puzzle for a long time till Opie in 1901 was able to localize the morbid changes associated with diabetes in the islands of Langerhans Heiberg* Weichselbaum† and Cecil as a result of investigations on a large number of diabetic cases claimed that pancreatic changes were present in almost every case and were limited to the islet cells alone in a sufficient number of cases to prove the insular theory

* Heiberg K A *Virchows Arch f Path Anat* 1911 204 179
† Weichselbaum A *Wien Klin Wchnschr* 1911 24 153

Cecil further called attention to the accumulation of evidence as regards regeneration or hypertrophy in the islands of Langerhans (34 per cent of the cases) Weichselbaum also suggested the presence of regenerative process in the islet cells—either cellular proliferation of the island epithelium or formation of new islands from the epithelium of the ducts

With the discovery of the method of differentiation of *alpha* and *beta* cells in the islands of Langerhans by Lane and the serial studies of Bensley (by his vital staining methods with pyronin) on the pancreas of guinea pigs it was hoped that there would be found some single universal diabetic lesion common to all cases unfortunately however further study in this direction gave disappointing results

Heiberg* by counting the number of islands per 50 c cm of the gland definitely found a marked decrease in the number of the islands in the diabetic pancreas (30 to 40 instead of an average normal of 130) He was of opinion that these quantitative changes were decisive factors in the ætiology of diabetes mellitus Weichselbaum after an extensive study emphasized the importance of these quantitative changes as dominating factors in the ætiology of the disease and described the following three main types of pancreatic changes as evidenced by various changes in the islet and gland tissues

(1) Hydrophic degeneration followed by atrophy

(2) Chronic interstitial pancreatitis causing connective tissue proliferation in the islands with subsequent sclerosis and atrophy

(3) Hyaline degeneration of the islands probably as a result of arteriosclerosis of the pancreatic arteries

Hyalinization of the islands of Langerhans is now considered to be the most typical pancreatic lesion in diabetes mellitus It is believed to be due to the production of an

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* *Pathology* Kaufman Vol II p 1036

inter-cellular substance by fibroblasts when the process is sufficiently advanced a number of epithelial cells are destroyed and the islet cells undergo hyaline degeneration being practically separated from the blood supply by a more or less impermeable membrane

Morbid Anatomy

There are not many diseases in which the post mortem examination of the body furnishes us with such scanty and insufficient information as in diabetes The author attended the post mortem of several cases of diabetes at St Bartholomew s Hospital in London and was struck with the fact that a good number of cases which during life showed undoubted symptoms of true diabetes mellitus did not reveal anything in particular at the post mortem examination except certain signs of denutrition

(1) *External appearances*—There is usually general wasting and sometimes extreme emaciation On the other hand it is not uncommon to find a well developed layer of subcutaneous fat in a patient who has died of diabetes

(2) *Brain*—In some cases where coma supervened before death congestion and œdema of the brain were common signs with marked thickening of the membranes and wasting of the convolutions in some cases The choroid plexus may be congested and thickened tumours in the region of the fourth ventricle and the medulla may be found

(3) *Spinal cord*—Dilatation of the central canal enlargement of the perivascular sheaths and localized softening may be found due probably to secondary nutritive changes Tumours of the cord have sometimes also been found

(4) *Heart*—The heart muscles are often found to be pale soft or even distinctly fatty Arteriosclerosis is fairly common The blood sometimes shows signs of distinct lipæmia

CHAPTER VII

DIAGNOSIS

The diagnosis of true diabetes mellitus is often an easy matter when the patient presents the usual signs and symptoms But there are many cases in which considerable difficulty is experienced and elaborate laboratory methods of diagnosis are necessary Some of these patients complain of unusual symptoms and the diagnosis of diabetes often comes from the ophthalmologist dentist neurologist or dermatologist whom the patient had occasion to consult for his ailments The author had many patients referred to him like this who did not have the usual classical symptoms but on detailed study proved to be cases of true diabetes and the unusual symptoms which had led them to see an ophthalmologist dentist or other specialist cleared up under treatment of diabetes alone

The mere presence of sugar in the urine does not justify one making a diagnosis of diabetes * though in practice it is safer to treat him as a diabetic until the contrary is proved by clinical and laboratory tests We know there are several conditions other than diabetes in which one may have transient or intermittent glycosuria Exophthalmic goitre diseases of the thyroid gland excessive thyroid medication acromegaly cerebral tumour gall stone cirrhosis of the liver (specially of the infantile type) renal glycosuria etc are common examples

In renal glycosuria the threshold level of the kidney for glucose is lowered so that the patient has glycosuria often with a normal blood sugar level This condition can

* It should be remembered in th s connect o that the ur ne wh ch [illegible] es not necessa [illegible] Re luc ng sub- [illegible] publ [illegible] n

be brought about experimentally in normal individuals by injection of Phloridzin

Renal threshold

The term renal threshold may be defined as that concentration of sugar in the blood which must be reached before glucose is eliminated in the urine The normal threshold value for glucose is generally assumed to be about the level of blood sugar at 0 180 per cent

It should be realized that this threshold level manifests itself in wide individual variations under certain conditions The renal threshold is usually *elevated* in nephritis arteriosclerosis and in long standing cases of diabetes in one of the author s cases blood sugar value as high as 0 450 per cent was seen without co existing glycosuria

The renal threshold is lowered in cases of renal glycosuria Some of the patients with renal glycosuria pass sugar in the urine for nearly the whole life the glycosuria apparenly doing them no harm It has been found that most of these patients who come for investigation have a low renal threshold i e they pass sugar in the urine with a normal or even subnormal blood sugar In two respects only these people are likely to come to any harm namely first that they are usually refused by the insurance companies which labour under the idea that glycosuria invariably means diabetes and secondly that when they happen to consult an inexperienced doctor for this innocent glycosuria they are often adjudged to be true cases of diabetes and are subjected to rigorous treatment In the old methods of treatment by diet and drugs not much harm could come to these patients except perhaps some loss in weight due to unnecessary low dieting and some personal discomfort but since insulin has come into general use the aspect of these unfortunate cases has taken a turn for the worse and the author could testify to several cases of such patients who were brought to a pitiable condition owing to irresponsible or uncalled for treatment by insulin

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The diagnosis of true matter when the patien symptoms But there are difficulty is experienced a of diagnosis are necessary of unusual symptoms and comes from the ophthalm matologist whom the pr his ailments The auth him like this, who did no but on detailed study, and the unusual sympt ophthalmologist denti under treatment of dia

The mere presen justify one making a d tice, it is safer to treat is proved by clinical are several conditions may have transient or mic goitre, diseases of medication, acrome cirrhosis of the liver (glycosuria, etc, are con

In renal glycosuria for glucose is lowered often with a normal bl

* It should be remember reduces an alkaline copper s rily contain sugar *Vide* at stances in the urine ther the *Indian Medical Gazette*

Note —

(1) How the rise of the blood sugar corresponds to the meals taken
In a normal healthy individual the maximum rise of blood sugar takes place between ½ to 1 hour after the meal is taken It comes down to normal level long before the next meal is due

In a mild case of diabetes the maximum rise of blood sugar takes place 1½ hours after the meal is taken It comes down before the next meal is due, but is often much above the original level

In severe cases of diabetes the blood sugar after the meal is taken, goes on rising and it does not usually get a chance of coming down before the next meal is due

(2) The blood sugar is at its lowest level in the early morning before the individual has any food— the fasting level of blood sugar as it is called

(3) The mild cases of diabetes are often sugar free in the morning and may also have a normal blood sugar level

The shadowed areas in the chart represent the blood sugar above the kidney threshold (about 0 18 per cent), where sugar appears in the urine

It has already been said that a normal healthy individual has a high capacity for the utilization of carbohydrates and large quantities of carbohydrates are ordinarily oxidized in the system without giving rise to glycosuria Generally speaking, glucose excretion in the urine cannot take place until the concentration of sugar in the blood goes beyond 0 18 per cent or thereabout—this level of blood sugar concentration, as stated before, being termed renal threshold level' or the leak point for glucose We have already seen how difficult it is to raise the blood sugar in a normal healthy individual above the renal threshold because as soon as the blood sugar reaches near the threshold level the sugar storage mechanism intervenes and prevents further rise of the blood sugar

In the case of the potential diabetic, or in cases of mild diabetes things are quite different The power of carbohydrate utilization and storage in these individuals are deficient in varying degrees and thus the effect of the ingestion of glucose on the blood sugar level of these patients differs markedly from that in normal healthy individuals

and this difference, as elicited by glucose tolerance tests has been utilized as a basis of investigation

The introduction of micro-chemical methods of blood analysis has rendered possible the repeated estimation of the blood sugar content at frequent intervals after the ingestion of glucose thus giving us an opportunity to study how the patient is responding to the sugar ingested This test would not only differentiate a non diabetic individual (who for some reason or other is passing sugar in the urine) from a true diabetic but would often help us in diagnosing the disease in the pre-diabetic stage

Glucose tolerance test

The procedure for a GLUCOSE TOLERANCE TEST is given below

Preparation of the patient —There should not be a too rigid restriction of the patient's diet prior to doing the glucose tolerance test The test should preferably be done with the previous diet of the patient unrestricted The morning (about the breakfast time i e 12 to 15 hours after the previous night's meal) is the best time to do it when the digestive activity is at its minimum The patient should as far as practicable be at perfect physical and mental rest

Before doing the test the patient empties his bladder and the urine is collected measured and examined for sugar At the same time a sample of blood is taken and its sugar content estimated This is known as the 'fasting level' of blood sugar

The patient is now given 50 to 100* grammes of glucose dissolved in 3 to 4 oz of water Half an hour after the glucose is given another sample of blood is taken and examined and this is repeated every half an hour for the

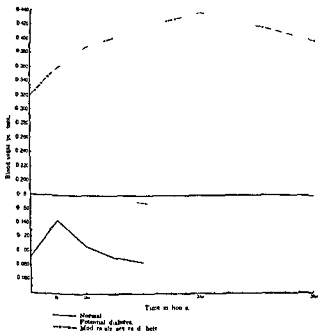
* According to the author blood sugar curves for diagnostic purpose can be obtained by the administration of 50 grammes of glucose and this amount is ordinarily used for routine work in the average adult cases

next 2 or 3 hours Specimens of urine are collected and examined preferably every hour

In the average healthy normal individual the concentration of sugar in the blood usually rises after the ingestion of glucose from the initial fasting level of about 0 1 per cent to a maximum of 0 14 to 0 15 per cent within one half to one hour and thereafter it goes down to the normal level within an hour or thereabout (*vide* Chart IV) Variations of course occur but as a general rule it may be taken for granted that the maximum concentration of blood sugar

CHART IV

Blood sugar curves in glucose tolerance tests



in the normal individual is to be looked for within one hour after the dose of sugar has been taken This highest point

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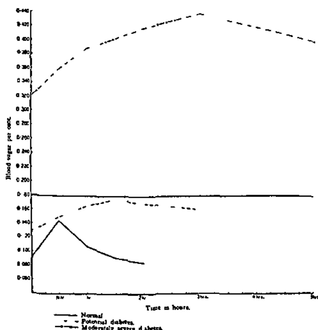
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In the average healthy normal individual, the concentration of sugar in the blood usually rises after the ingestion of glucose, from the initial "fasting level of about 0 1 per cent to a maximum of 0 14 to 0 15 per cent, within one half to one hour and, thereafter, it goes down to the normal level within an hour or thereabout (*vide* Chart IV) Variations of course occur but as a general rule, it may be taken for granted that the maximum concentration of blood sugar

CHART IV

Blood sugar curves in glucose tolerance tests



in the normal individual is to be looked for within one hour after the dose of sugar has been taken This highest point

in the blood sugar concentration varies in different individuals but the safe maximum normal limit may be fixed at 0 17 per cent As soon as the blood sugar level has reached this concentration the sugar storage mechanism comes into operation which abstracts sugar from the blood more quickly than it is absorbed and converts it into glycogen The mechanism for this is very efficient in the normal healthy individual The author tried four half hourly 50 gramme doses of glucose on himself but he was unable to force the blood sugar to go above 0 165 per cent

As soon as the storage mechanism intervenes and the tissues and the liver begin to abstract sugar from the blood storing it as glycogen the blood sugar falls abruptly and within an hour and a half after the ingestion of sugar it comes down to normal or sometimes below the normal level

Summarizing the results of the glucose tolerance test in a healthy *normal individual* we find that —

(1) The fasting blood sugar level is normal

(2) The maximum rise of blood sugar after 50 grammes of glucose have been ingested is within 1 hour and is not above 0 17 per cent

(3) *The drop of the* blood sugar to the *normal* level takes place within 1½ hours after the glucose is taken

(4) *No glycosuria occurs*

Now if the test is done in a case of *potential diabetes* we are likely to meet with the following results —

(1) The fasting level of blood sugar may *be* normal or slightly *higher*

(2) The blood sugar afte ... testmeal of 50 grammes of glucose will however ... se ... the maximum rise of blood sugar will tak ... m ... interval than in the nor ... l The ... u ... very near to ... nt or ... yond the leak ... the ... e

(3) ... not abrupt

(4) The results drawn on a graph paper will show a long drawn out flat top blood sugar curve which is suggestive of a delayed carbohydrate assimilation (*vide* Chart IV)

The result of the glucose tolerance test in a case of *true diabetes* is very striking

(1) The blood sugar goes on rising and the maximum rise (sometimes reaching a very high figure) may not take place till the end of 3 or 3½ hours after the ingestion of glucose

(2) The fall of blood sugar also takes place slowly the original level of blood sugar (i e the level before the ingestion of glucose) not usually being reached till the end of 5 or even 6 hours according to the varying degrees of defect in the storage mechanism

(3) As a matter of fact the severity of diabetes can be gauged by the type of curve obtained after the glucose ingestion

(4) The kidneys actively excrete glucose all the time and the amount of increase of sugar in the urine after the dose of glucose is an additional evidence of the nature and severity of the case (*vide* Chart IV)

Thus we see that the glucose tolerance test if properly done and interpreted is not only one of the best and quickest methods of differentiation between a non diabetic and a diabetic individual but it also helps us in getting an idea of the nature and severity of the disease if the case proves to be one of diabetes

A few practical points for consideration

There are however a few practical points which must be taken into consideration in properly adjudging and interpreting the results of the test For example the previous diet of the patient appears to the author to be a very important factor It has for instance been definitely found that if a diabetic patient lived on a very low carbohydrate diet for several days before the test or starves himself for

two or three days prior to submission to the test the hyperglycæmic response to the ingestion of glucose will be much more marked than if the patient had lived on a more liberal carbohydrate diet previous to the test and the results thus obtained will give us a false impression about the nature and severity of the case

The evidence that starvation causes a lowering of carbohydrate tolerance even in normal individuals has further been found by the author in a recent work while engaged *on metabolic studies* in starvation cases during the last Bengal Famine 1943 * Among other interesting findings the author was able to show that short but acute starvation caused a marked lowering of the carbohydrate tolerance Glucose tolerance tests done on these cases showed that in the majority the blood sugar curves obtained after a glucose meal simulated *diabetic* curves of varying degrees of severity Prolonged malnutrition on the other hand was found to cause a defective absorption of glucose from the alimentary tract resulting in an almost straight blood sugar curve after the glucose meal Blood sugar curves of a similar nature were also obtained in cases of sprue and acute anaemia

Working on this question namely the effect of the duration of fast on hyperglycæmic response after glucose ingestion Staub came to the conclusion that the *maximum* glucose tolerance (or in other words the *minimum* hyperglycæmic response to glucose) was obtained 14 hours after the previous meal and that the glucose tolerance began to decrease gradually as the period of fasting was increased The best time to do the glucose tolerance test therefore, is about breakfast time about 14 to 15 hours after the previous night s meal It is also evident to us that the patient should not be on a too rigid diet prior to being submitted to the glucose tolerance test It is interesting to note here that the diabetic patient applying for an insurance policy

* A preliminary study of the biochemical changes in starvation cases Indian Journal of Medical Research 34 1 May 1946

who thinks he can elude the doctor either by fasting or living on a very rigid diet before appearing for the test defeats his own ends

The effect of a low carbohydrate diet on the carbohydrate tolerance of the diabetic patient will be further discussed in the chapter dealing with the dietetic treatment of diabetes

Illustrative Cases

The following results were obtained by glucose tolerance tests on a few typical cases and are inserted below by way of illustration —

Case I —K P T aged 45

Refused by insurance companies several times for glycosuria which happened to be intermittent No physical signs and symptoms of diabetes No glycosuria occurred after a dose of 50 grammes of glucose

The result of the glucose tolerance test was as follows

	Per cent
Blood sugar before giving glucose	0.081
½ hour after 50 gm of glucose	0.146
1	0.150
2 hours	0.081

Interpretation of result —The individual behaved exactly like a *normal person* Sugar storage mechanism perfectly normal

Case II —E P

Intense sciatica for 10 or 15 days Urine showed a trace of sugar Another brother had slight glycosuria and albuminuria for a long time

The result of the glucose tolerance test was as follows

	Per cent
Blood sugar before giving glucose	0.105
½ hour after 50 gm of glucose	0.116
1	0.140
2 hours	0.105
Urinary sugar before test	*Nil*
2 hours after 50 gm of glucose	Traces

Interpretation of result—The blood sugar curve was perfectly normal but the kidney threshold was lower than normal

The case is one of *renal glycosuria*

Case III—P S, aged 29

Was excessively stout Referred to the author by an insurance company for over weight

The result of the glucose tolerance test was as follows

	Per cent
Blood sugar before giving glucose	0 108
½ hour after 50 gm of glucose	0 175
1	0 16[illegible]
2 hours	0 1[illegible]5
Urinary sugar before test	Nil
2 hours after 50 gm of glucose	Nil

Interpretation of result—Definite defect in the sugar storage capacity The blood sugar continued to rise even at the end of 2 hours and nearly reached the threshold limit

This condition in a young man should be looked upon with suspicion as a *pre diabetic* stage

Case IV—J C F, aged 32

Had kept very good health till about a month previous to examination when suffered from a crop of boils No clinical signs and symptoms of diabetes

The result of the glucose tolerance test was as follows

	Per cent
Blood sugar before giving glucose	0 110
½ hour after 50 gm of glucose	0 14[illegible]
1	0 176
2 hours	0 18[illegible]
Urinary sugar before test	*Nil*
2 hours after 50 gm of glucose	0 9

Interpretation of result—The sugar storage mechanism was definitely *defective and this happening in a young* man was indicative of *early diabetes*

Case V—P R R, aged 35

Refused by insurance company for glycosuria No visible symptoms present but on close questioning the

patient admitted of thirst and polyuria which he thought to be due to climatic conditions

The result of the glucose tolerance test was as follows

	Per cent
Blood sugar before giving glucose	0 1[illegible]
½ hour after 50 gm of glucose	0 1[illegible]6
1 „	0 217
2 hours	0 179

Urine before giving glucose showed no sugar but 2 hours after 50 gm of glucose the sugar rose to 3 1 per cent

Interpretation of result—The sugar storage mechanism fairly defective Result should be regarded as indicative of *mild diabetes* and the patient should be treated accordingly

Case VI—*W* (*Scotsman*) *aged* 50

Eighteen months history of glycosuria which disappeared on regulation of diet Not much physical discomfort

The result of the glucose tolerance test was as follows

	Per cent
Blood sugar before giving glucose	0 098
½ hour after 50 gm of glucose	0 167
1 „	0 259
2 hours	0 218

The urine passed before test was sugar free but it rose to 4 per cent 2 hours after 50 gm of glucose

Interpretation of result—Sugar tolerance fairly defective though the sugar storage mechanism came into action one hour after the glucose meal as in a normal person the rate of storage by the liver and tissues was poor

The patient should be regarded as *a case of diabetes mellitus*

Case VII—*Mrs W B*, *aged* 38

Sugar discovered in the urine about six months previous to examination Kept fairly good health till about a month ago when she suddenly began to lose weight

The result of the glucose tolerance test was as follows

	Per cent
Blood sugar before giving glucose	0 280
½ hour after 50 gm of glucose	0 340
1	0 3[illegible]0
2 hours	0 470

The urine before the test showed 2 4 per cent sugar which rose to 6 per cent 2 hours after 50 gm of glucose

Interpretation of result—Sugar tolerance markedly defective The initial hyperglycæmia was fairly marked The hyperglycæmia resulting from the ingestion of 50 gm of glucose was well marked and persisted for an abnormally long period provoking but a poor response from the sugar storage mechanism There was a sharp increase of glycosuria 2 hours after the glucose meal

Such a marked diminution in sugar tolerance indicated *a fairly severe type of diabetes mellitus*

We thus see that the glucose tolerance test, if properly done and interpreted is one of the most valuable and indispensable means for determining the nature of the glycosuria one is called upon to deal with It gives us a satisfactory clue as to whether the glycosuria is diabetic in origin or otherwise and is also indicative of the degree of severity if the glycosuria proves to be diabetic in origin

Correct interpretation of results

A word of caution should be given regarding the correct interpretation of the results of the glucose tolerance tests Mention has already been made about the influence of the previous diet of the patient on the results of the test Among other factors which may also seriously affect the response of the diabetic individual to the glucose meal may be mentioned —severe infections of any kind toxæmia ingestion of thyroid extract previous administration of insulin etc These factors should be kept in mind while interpreting results

It should also be borne in mind that apart from diabetes certain other conditions may give rise to abnormal findings after a glucose tolerance test the principal amongst them being diseases of the liver hyperthyroidism hypertension nephritis acute starvation sprue acute anaemia etc *Table III given below includes averages obtained in a* number of these conditions In interpreting the results of glucose tolerance tests therefore all these factors should be borne in mind and the diagnosis must be based upon evaluation of as much evidence as is available in each individual case

TABLE III

Average Blood sugar values following administration of 50 Gms of glucose

	Blood-sugar—Mgs per 100 c c						
	Fasting	½ hour	1 hour	1½ hours	2 hours	3 hours	Urine sugar
Acute starvation	85	150	200	210	215	215	Traces
Prolonged Malnutrition	71	72	72	72	75	9	Nil
Sprue	96	96	96	90	90	91	Nil
Hypertension	110	170	180		160	130	Nil
Nephritis	140	180	200		185	185	Nil
Hyperthyroidism	100	200	150		170	110	Nil or traces
Hepatic diseases	156	195	180	165	155	130	Nil
Lag storage curve	100	200	140	100			+

It would not be out of place to mention in this connection that the estimation of the cholesterol content of the blood* (*vide* Chapter VIII) in cases of diabetes gives a valuable index as regards the severity of the case and its prognosis The estimation of the inorganic phosphate content of the blood after a glucose meal as evidenced by the recent work of the author† also gives much valuable information as regards the rate of utilization of sugar in the tissues

* *Indian Journal of Medical Research* 24 2nd October 1936
† *Indian Journal of Medical Research* January 1939

The result of the glucose tolerance test was as follows

	Per cent
Blood sugar before giving glucose	0 290
½ hour after 50 gm of glucose	0 340
1	0 3 0
2 hours	0 4 0

The urine before the test showed 2 4 per cent sugar which rose to 6 per cent 2 hours after 50 gm of glucose

Interpretation of result—Sugar tolerance markedly defective The initial hyperglycæmia was fairly marked The hyperglycæmia resulting from the ingestion of 50 gm of glucose was well marked and persisted for an abnormally long period provoking but a poor response from the sugar storage mechanism There was a sharp increase of glycosuria 2 hours after the glucose meal

Such a marked diminution in sugar tolerance indicated *a fairly severe type of diabetes mellitus*

We thus see that the glucose tolerance test if properly done and interpreted is one of the most valuable and indispensable means for determining the nature of the glycosuria one is called upon to deal with It gives us a satisfactory clue as to whether the glycosuria is diabetic in origin or otherwise and is also indicative of the degree of severity if the glycosuria proves to be diabetic in origin

Correct interpretation of results

A word of caution should be given regarding the correct interpretation of the results of the glucose tolerance tests Mention has already been made about the influence of the previous diet of the patient on the results of the test Among other factors which may also seriously affect the response of the diabetic individual to the glucose meal may be mentioned —severe infections of any kind toxæmia ingestion of thyroid extract previous administration of insulin etc These factors should be kept in mind while interpreting results

It should also be borne in mind that apart from diabetes certain other conditions may give rise to abnormal findings after a glucose tolerance test the principal amongst them being diseases of the liver hyperthyroidism hyper tension nephritis acute starvation sprue acute anaemia etc Table III given below includes averages obtained in a number of these conditions In interpreting the results of glucose tolerance tests therefore all these factors should be borne in mind and the diagnosis must be based upon evaluation of as much evidence as is available in each individual case

TABLE III
Average Blood sugar values following administration of 50 Gms of glucose

	Blood sugar——Mgs per 100 c c						Urine sugar
	Fasting	½ hour	1 hour	1½ hours	2 hours	3 hours	
Acute starvation	85	150	200	210	215	215	Traces
Prolonged Malnutrition	71	72	72	72	75	79	Nil
Sprue	96	96	96	90	90	94	Nil
Hypertension	110	170	180		160	130	Nil
Nephritis	140	180	200		185	185	Nil
Hyperthyroidism	100	200	150		120	110	Nil or trace
Hepatic diseases	156	195	180	165	155	130	Nil
Lag storage curve	100	200	140	100			+

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CHAPTER VIII

BLOOD SUGAR AND BLOOD LIPOIDS

Normal Fasting blood sugar level

As a result of a very large number of blood sugar determinations on people of different races during the last 25 years the author has come to the conclusion that the blood sugar level of healthy normal Indians after an over night fast *is remarkably constant the average value being* 100 mgs per 100 c c of blood with individual variations from 80 to 110 mgs This would also show that the blood sugar level of healthy normal Europeans does not differ materially from that of Indians and that race *per se* has no *influence on the blood sugar level* *

A value of 70 mgs on the low side and 120 mgs on the high side has sometimes been obtained these being con sidered as a low or high level normal value A fasting blood sugar value of over 120 mgs per 100 c c should be viewed with suspicion

The total amount of sugar present in the circulating blood is about 5 grammes

Micro chemical methods of blood sugar estimation — The micro chemical mehtod of blood analysis was introduced by *Bang in 1913* resulting in a widespread clinical applica tion of blood sugar determination Even such a small amount of blood as 0 1 c c (which can be obtained from a finger prick) is now sufficient for an accurate estimation blood sugar

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* *Bose J P Trans F E A T M* Seventh Congre p 150

Sugar content in the capillary (arterial) and the venous blood *

It is now common knowledge that the sugar content of the capillary (arterial) blood represents such an amount of glucose as has been supplied to the muscles and tissues and thus would under certain conditions be higher than the sugar content of the venous blood which represents the remaining amount of glucose after a portion has been eliminated or utilized during its passage through the tissues

In healthy normal individuals the initial (i e fasting) level of sugar in both the capillary and the venous blood has been found to be practically identical but after the ingestion of glucose the rise in the sugar content in the capillary (arterial) blood is more rapid and pronounced than in the venous blood This is chiefly due to direct absorption of the glucose from the intestines and partly according to some to hepatic glycogenolysis i e liberation of the glucose from the glycogen store house of the liver The sugar content of the venous blood as has already been stated would naturally be somewhat lower because during its passage through the tissues particularly the muscles some portion of the sugar is removed for the formation of muscle glycogen and for eventual utilization The difference between the sugar content of the arterial and the venous blood (arterio venous difference as it is called) specially after glucose ingestion therefore roughly indicates the rate of glucose utilization in the muscles and tissues

But while in a normal healthy individual the fasting level of sugar content of both the capillary and the venous blood is practically identical it is not so in severe diabetic conditions The mechanism both of storage and utilization of sugar in the tissues being markedly defective (as a result of the disease) the fasting level of sugar in the venou

* Arterio Venous Sugar difference [illegible] betes mellitus—Bose J Indian Journal Medical Re[illegible] III J I 1935

blood may be and often is higher than in the capillary blood This fact has frequently been taken advantage of as a simple means of determining the nature and the severity of the disease

Distribution of sugar in the blood

Until 1908 it was believed that the whole amount of sugar present in the blood was contained in the plasma and that the corpuscles contained no sugar at all Michaelis and Rona in 1909 were probably the first investigators to demonstrate by experiments on dogs that blood corpuscles also contained sugar though according to them there was no constant relationship between the corpuscular sugar and the plasma sugar The author made a study of the distribution of sugar in the blood of diabetic and non diabetic subjects* and has among other things come to the following important conclusions —

(1) That in normal healthy individuals the concentration of sugar both in the plasma and the corpuscles are almost identical

(2) That in diabetic subjects things are quite different Here the plasma sugar is always higher than the corpuscular sugar

(3) That the increase of the plasma sugar over the corpuscular sugar in cases of diabetes mellitus happens according to the severity of the disease in other words the graver the disease the higher is the ratio of the plasma sugar to the corpuscular sugar This according to the author is due to the inability of the corpuscles to take in and utilize sugar from the surrounding plasma

(4) In the author s opinion the estimation both of the plasma sugar and the corpuscular sugar in cases of diabetes mellitus will give a truer and better indication of the nature of the disease than estimation of the whole blood sugar alone and the determination of the plasma

* Bose J P *Indian Medical Gazette* Vol LXVII No 10 page 415

corpuscular ratio will give a much better indication of the severity of the disease

(5) Administration of insulin in cases of diabetes mellitus increases the permeability of the corpuscles to sugar intake helps in the utilization and storage of sugar within their own walls and thus brings the plasma corpuscular ratio down to normal

Glycolysis in normal and Diabetic blood

That sugar gradually disappears from the blood if allowed to stand *in vitro*, has been known for a long time but on looking up the literature on the subject it appears that there is no uniformity of opinion among the different workers who studied this subject from different points of view

The problem of glycolysis of blood in normal subjects in the tropics attracted the attention of the author a few years ago when he was studying the effect of temperature and the different anti coagulants on glycolysis in normal blood *

It was found that the blood lost its sugar content if left at room temperature and the higher the temperature the more rapid was the loss of sugar As a matter of fact it was found that in some of the samples the loss of sugar after the sample was left at room temperature for 6 hours was nearly 70% This important factor not having been taken into consideration in the past gave rise to different and conflicting results when the same sample of blood was examined at different intervals after its collection

Another significant and important finding was that if the blood was left in cold storage the loss of sugar became negligible It was also observed that if sodi fluoride was used as an anti-coagulant instead of pot citrate or oxalate which are commonly used the loss of sugar even in ordinary

* Bose J I and De L N *Indian Journal of Medical Research* 30 Jan 194?

temperature was negligible even after 12 hours This was a very important finding as it solved the problem of examination of samples of blood for sugar sent from distant places

Experiments on diabetic blood* however showed that under similar conditions the samples of diabetic blood behaved absolutely differently from normal blood as regards the rate of glycolysis The loss of sugar was found to be extremely slow and in some samples collected from severe cases of diabetes there was practically no loss of sugar even when the samples were left at room temperature for a considerable period The rate of glycolysis in the blood of mild cases of diabetes however did not differ materially from that observed in normal cases

It has also been observed that the rate of glycolysis of diabetic blood depended on the severity of the diabetic condition The greater the severity the lower was the loss of sugar This important and significant finding has since been utilized by the author as a factor in assessing the severity of the diabetic condition

Regulation of the blood sugar level—the influence of the endocrine glands

We know that in a healthy normal individual the fasting level of the sugar content of the blood remains practically at a constant figure It usually increases after each meal and decreases after the effect of the meal has passed away The mechanism by which the amount of sugar in the blood is regulated and kept at a constant level is however a very complicated process We know that there are two groups of ductless glands with antagonistic actions which control this mechanism one group consists of the suprarenals the thyroid and the pituitary the

* Bose J P and De L N *Indian Journal of Medical Research* 33 May 1945

tendency of each of the glands being to mobilize sugar into the blood and cause hyperglycæmia. The other group known also as the opposing group consists mainly of the pancreas (and possibly the parathyroids) the internal secretions of which, *i.e.*, insulin tend (expressed in simple language) to check the hyperglycæmia. The secretions of the former group are influenced by the sympathetic system and those of the opposing group by the parasympathetic system.

For some time past the author has been working on the problem of the inter-relationship of and the antagonistic action as between the above named endocrine glands in regard to their influence on sugar metabolism and several papers have been published on the subject.* It is not the object of this book to discuss them in detail. It will be enough to say for instance that adrenalin acts antagonistically to insulin and that this action is not a direct neutralization of insulin by adrenalin but an indirect one. Adrenalin is believed to act through the liver by converting liver glycogen into sugar and mobilizing it into the blood thus tending to raise the blood sugar level. Insulin on the other hand causes the excess of sugar in the blood to be taken up by the muscles which store it up as muscle glycogen for final utilization thus tending to bring the blood sugar level down. It thus becomes clear why adrenalin is a very useful antidote in the treatment of insulin hypoglycæmia.

That there is some relationship between the action of the suprarenal bodies and the thyroid gland is undoubted though the evidence is not conclusive on the point whether this relationship is a direct one. Thyroid like the suprarenals acts antagonistically to insulin.

The adrenals as has just been said act through the splanchnic nerve and the hepatic plexus causing a release

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* Bose J P *Trans F E A T M* Seventh Congress Vol III p 335

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* Bose J P and De U N *Indian Journal of Medical Research* 33 May 1945

action of the hormone of the anterior lobe of the pituitary gland seems to be one of insulin antagonism *i e*, it acts by opposing the effect of insulin in the tissue thus inhibiting its power of glycogen formation in the muscles (glycogenesis) and final utilization It has also been suggested that the pituitary hormone secures its objective through the intermediation of the suprarenals

To summarize the normal process of the regulation of blood sugar it thus appears that the concentration of sugar in the blood is the resultant of two main forces —

(1) Those which affect the liberation of glucose from the glycogen store house of the liver

We have seen that the main function of the hepatic glycogen is only to supply glucose to the circulating blood according to the changing needs of the organism and in this it is helped by the suprarenals and the thyroid in the maintenance of the blood sugar level The hepatic glycogen unlike the muscle glycogen does not directly supply glucose for tissue utilization

(2) Those which affect its withdrawal from the blood stream for deposit as glycogen in the tissues and its final utilization

We know that during the metabolic activities in the muscles they draw upon their glycogen reserve to supply them with glucose for combustion, to make good the loss more glucose is abstracted from the circulating blood to be transformed into muscle glycogen and kept in store for future combustion in the tissues whenever required This phase of carbohydrate metabolism is dependent upon the action of insulin* and it is this action of insulin that pituitrin appears to antagonise, *i e*, it depresses the glycogen formation in the muscles

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* In cases of diabetes mellitus where there is deficiency of insulin in varying degrees the excess of glucose in the circulating blood is incapable of being transformed into muscle glycogen or utilized in the tissues

of sugar from the glycogen store house of the liver, thus tending to cause hyperglycemia It is believed that the thyroid helps to intensify this action to a great extent The author has shown by experiments on rabbits that when the thyroid is removed the animals react in a markedly less degree to adrenalin stimulation than before the operation * Another very important observation made by the author was that these thyroidectomized rabbits became highly sensitive to insulin

The results of the author s experiments tend to show that the absence or deficiency of thyroid secretion *depresses* the function of the adrenals to an appreciable extent but enhances the activity of insulin to a remarkable degree Thyroidectomy probably depresses the functions of the chromaphil tissues Normally thyroid secretion is believed to be *a direct stimulant to the chromaphil tissues causing them to yield adrenalin to blood in large quantities and the excess of adrenalin thus secreted through such stimulation acts through the splanchnic nerve and the hepatic plexus* and causes a release *of sugar from the liver glycogen*

It thus appears that thyroidectomy alters the glycogenolytic response of the liver to adrenalin stimulation and hence enhances the activity of the insulin producing cells of the pancreas Some observers have noted that the inhibitory action on the pancreas is removed to a large extent after thyroidectomy and that there is a distinct increase in the islet cells of the pancreas after the thyroid is removed The thyroid like the suprarenals thus takes a considerable share in the regulation of the level of blood sugar

The pituitary gland is also believed to take an important part in this connection Cushing has shown that intravenous injection of extracts from both the anterior and the posterior lobes diminish the tolerance of experimental animals to glucose It has already been stated that the

* *Bose J P Indian Jo rnal of Med cal Research* 18 N 1

While the value of limitation of fat in the diabetic diet was slowly gaining ground Newburgh and Marsh in 1920 showed exceptional courage in coming forward with their theory advocating high fat diet in the treatment of diabetes. They showed that diabetic diet containing as much as 200 grammes of fat daily was not only not injurious to the diabetic patients but that they improved considerably on such a diet This was corroborated by Blatherwick who further showed that the fat content of the blood actually fell as a result of such treatment

In view of such conflicting observations it was not surprising that the method of treatment of diabetes by high fat diet as advocated by Newburgh and Marsh was looked upon with fear (of acidosis) but the result of the treatment in causing marked clinical improvement negatived such apprehension As a matter of fact efforts were made to discover the cause of this apparent anomaly and it was found that the real cause of the clinical improvement was not the high fat diet but the principle of under nutrition which was combined with it The total calories allowed by this fat diet was only 1 000 in the beginning and the usual maximum reached was about 1 800

Blix in 1926 further showed that if the metabolic activities in the diabetic were kept low the clinical symptoms ameliorated and the lipæmia vanished even when the patients took as much as 200 grammes to 250 grammes of fat daily

It must be admitted that though the principles of dietetic treatment as advocated by these authors are not applicable to-day their work deserves recognition in the sense that they have shown that when diabetic patients are put on larg quantities of fat they do not develop acidosis and co when they are protected by under nutrition y ha caloric iet with the minimum protein own ir t ation of this form of treat f l e future of the diabetic

Blood Lipoids in Diabetes *

For several years past increasing interest has been taken on the significance of cholesteremia in diabetes and the part it plays in the prognosis and complications of the disease In the old days when phlebotomy used to be one of the methods in the treatment of diabetes milkiness of the diabetic blood used to be a common finding in the severe cases especially those with associated nephritis Later on the cream which separated out from the milky serum was recognised to be fat and the condition was recognized as lipæmia

Seo in 1909 was *probably the first to draw pointed* attention to the fact that similar lipæmia could be produced in experimental diabetes in animals by the *removal of the* pancreas This has since been corroborated by other workers

Professor Bloor who *had done a considerable amount* of work in connection with the fat content of blood in health and disease definitely showed that the lipoid (fat) content of the blood in the average diabetic was much higher than in the normal This was corroborated by Gray and others

Bloor s findings thus led to important and interesting consequences Joslin in 1917 went more deeply into the problem and concluded that the diabetic state was respon sible for producing some defect in the mechanism for the transportation disposal or metabolism of fat It was also shown experimentally that feeding diabetic patients with fat increased the lipoid content of the blood Emphasis was thus laid on the fact that limitation of fat in a diabetic diet would be advantageous The necessity of its total dietary regulation in the treatment of diabetes as advocated by Allen in 1919 appears to be a direct result of such a finding

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* Bose and De *Indian Journal of Medical Research* 24 2nd October 1936

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Cholesterol content of plasma in normal subjects

In healthy normal individuals the average cholesterol content of the plasma has been found to be 140 mg per 100 c c the range of *variation being 120 mg to 160 mg* pe cent It has also been observed that the cholesterol conten of the blood (plasma) of healthy normal Indian subjects doe not differ materially from the standard European an American figures thus showing that like blood sugar, th plasma cholesterol does not show any material raci difference

Cholesterol metabolism

There is a good deal of controversy, with regard to tl identity of the organ concerned in the metabolism cholesterol It appears to us that the consensus of opini tends to support the theory that it is the reticu *endothelial system which governs and regulates this me* bolism i e it tends to remove cholesterol from the bl when it is in excess and return it to the blood when cholesterol content becomes low in the blood Tl according to this view, a persistent hypercholesterc indicates a condition of hypoactivity of the retic endothelial system and a persistent hypocholesterc indicates a condition of hyperactivity of the system

According to all observations the liver appears to an important part in *the intermediary metabolism* an the elimination of cholesterol the chief source of eli *tion appearing* to be the bile through the agency (polygonal cells of the liver

Cholesterol metabolism in diabetes

It has been stated that a condition of hyperlip be produced in experimental diabetes in anim removal of the pancreas It has also been stated workers that lipæmia is rather constantly diabetes mellitus, though as has been sugg

Slyke and Peters in 1931 these may only mean an abnormal localization of lipoids in the blood rather than an impairment of the metabolic process

It has also been suggested that diabetic lipæmia is indicative of a demand for metabolism of fat because of the unavailability of carbohydrate fuel This hypothesis appear to be reasonable in view of the fact brought out by several workers that the degree of hypercholesteremia is more or less an accurate indication of the severity of the disease It appears to be particularly true in several untreated cases in some of whom extremely high figures (a few being above 1 000 mg per 100 c c and several above 500 mg per cent) have been reported Joslin has described a case of diabetic coma where the cholesterol content of blood was 1 420 mg per cent This case did not recover

According to the observations made by the author the cholesterol content of the blood in diabetic subjects varies according to the severity of the diabetic condition Another observation made was that the extent of hypercholesteremia bears little relationship to the state of hyperglycæmia Cases showing extreme cholesterol values may show only moderate hyperglycæmia Extreme hyperglycæmia on the other hand may be associated with normal cholesterol content of the blood

It was further observed that the majority of the cases of diabetes showing a normal cholesterol value of the blood did not have any complications though the hyperglycæmia in some of them was well marked whereas cases showing moderate or marked hypercholesteremia almost invariably had complications and the response to treatment was usually unsatisfactory

Arteriosclerosis was found to be a fairly common complication in chronic diabetes the exciting cause in most cases being hypercholesteremia

We are thus faced with the interesting and important question as to whether there is any direct relationship

characteristic needle shaped cholesterol crystals and fatty acids which sooner or later combine with calcium These calcium soaps become calcareous giving rise to an atheromatous condition of the artery

We thus see how arteriosclerotic changes in the chronic diabetic occur helped by a state of hypercholesteremia predisposed no doubt by a state of persistent hyperglycæmia We cannot do better than quote Joslin who in his inimitable way states that with an excess of fat (obesity) diabetes begins and from an excess of fat the diabetics die—formerly of acidosis now of arteriosclerosis Arteriosclerosis now causes more than one half of all diabetic deaths

CHAPTER IX

PRINCIPLES OF DIETETICS AND THEIR APPLICATION IN THE TREATMENT OF DIABETES

WE know that food is required for two main purposes

(1) *To supply materials for the growth of the body and to replace the loss that is constantly taking place due to muscular and other activities*

(2) To supply energy for conversion into heat and work

The six nutritive principles of food are —

(1) Protein
(2) Carbohydrates
(3) Fats
(4) Minerals
(5) Water
(6) Vitamins

These are contained in varying proportions in the different foodstuffs some of which are composed of not more than one or two of these principles

Proteins or nitrogenous food (such as fish meat eggs milk cheese *chhana dal* etc) —The building up of the muscles and other tissues of the body and the repairing of their loss are the main functions of the protein foods The lack of the requisite amount of protein in one s diet leads to wasting a low state of health and diminished resisting power of the body tissues Neither fats nor carbohydrates can take any part in this process of tissue building and repairs

Carbohydrates —These mainly consist of sugars and starches being chemically composed of carbon hydrogen and oxygen the proportion of hydrogen and oxygen being the same as in water Their chief function is to produce

heat and energy for work Carbohydrate foods also take part in the formation of body fat and this is one of the reasons why excessive indulgence in rice potatoes and sweet meat makes one stout

Fats—This group consists of butter *ghee* and other animal fats and vegetable oils These like carbohydrates do not contain any nitrogen but are composed of carbon hydrogen and oxygen only though the proportion of oxygen in fat is much less than in carbohydrates The main function of fats in one s food is to produce heat and energy like the carbohydrates they are no good in tissue repairs The fats however do not burn in the system as readily as the carbohydrates but they produce more than double the quantity of heat

In addition to the above different kinds of minerals *water* and *vitamins* play an important part in the nutrition of the body and in activating and controlling its metabolism

A normal diet should consist of a mixture of all these principles of food in due proportions which vary according to race climate age sex body weight and occupation in life

Of the first three classes of food mentioned above the proteins being the only nitrogenous food are mainly responsible for the repair of body waste and for the building up of muscles and other tissues Without going into details as to the method by which the amount of protein required in a normal state of health is determined it may be stated that the average requirement for an adult person should be about 1¼ grammes per kilo of his body weight Roughly speaking an average healthy adult doing ordinary work requires about 90 grammes of protein per day

The amounts of carbohydrates and fats vary widely according to race climate work to be done etc but between them they must supply the total amount of energy required by the individual Proteins too produce energy but to a much less extent and are not generally drawn upon

if the supply of the other two kinds of energy producing food is sufficient

Caloric value of food

The potential energy contained in the first three proximate principles of food is measured by the amount of heat they produce on complete combustion in a calorimeter It has been estimated that 1 gramme of fat produces 9 3 calories of heat while 1 gramme of protein and 1 gramme of carbohydrate produce 4 1 calories each *A calorie is the unit of heat and is the amount of heat required to raise the temperature of one kilogramme of water by 1°C, i e, 4 lbs of water about 1°F*

Caloric requirement

The exact amount of calories required by an individual per day varies according to his body weight and the amount of work he has to perform that is the amount of calories he expends It has been estimated and as a working rule it may be taken for granted that an individual at *rest* requires about 30 calories per kilo (2 2 lbs) of his body weight per day and if the requisite quantity is not supplied by food it is produced by the process of the internal combustion of the tissues of the individual leading to wasting of the body

We thus see that for supplying heat and energy the requisite amount of calories must be supplied by food and that the utmost use should be made of fats on account of their ability to supply more calories per gramme than either proteins or carbohydrates But the use of fats is limited by the consideration that *without the aid of carbohydrates they cannot be completely* oxidized It has been rightly *stated* that the fat of food burns in the flame of carbohydrates within the system and in cases of diabetes it is a well known fact that a defective fat metabolism accompanies subnormal carbohydrate combustion The right proportion of fat to carbohydrate in a normal diet has been

estimated as 1 to 6. The standard amounts of the various constituents of an average diet as given by HUTCHINSON are given below :—

Proteins	100 grammes
Carbohydrates	450
Fat	75

Working out the caloric value of the above diet we get the following figures representing the number of calories daily required by an adult healthy man engaged in ordinary work :—

Protein	100 gm. × 4.1 =	410 calories
Carbohydraes	450 gm. × 4.1 =	1,845 calaries
Fat	75 gm. × 9.3 =	697 calories
	TOTAL	2,952 calories

Besides the standard amounts of the various constituents stated above a well balanced normal diet should contain requisite amount of minerals and an adequate supply of vitamins.

The average daily mineral requirement of a normal healthy individual is considered to be the following :—

Calcium	10 mg.
Iron	0.2 mg.
Phosphorus	15 mg.
Magnesium	0.3 mg.
	per kilo of body weight

Dietetic treatment of diabetes

Coming now to the dietetic treatment of diabetes we see that the fundamental principle underlying it is the administration of such an amount of carbohydrate food as is within the tolerance or limits of utilization of the patient so as to give rest to the pancreas.

Much laborious investigation for finding out a purely dietetic treatment of diabetes has been carried out all over the world and many empirical systems of treatment (such as skimmed milk, potato, oatmeal cures, etc.) have come an

gone A rational method of dietetic treatment applicable *to all classes of diabetes* has yet to come though lately much research work has been done in this direction The main idea of the dietetic treatment of diabetes now lies in the fact that the metabolism *must be kept low and* therefore the patient should be given only such an amount of *food as is necessary* to meet the *minimum metabolic requirement* of his body so as to prevent drawing upon his *own tissues* WILDER and his associates after a prolonged study came to the conclusion that the power of the glucose utilization of the patient varied inversely to his metabolic rate i e when the metabolic rate was at a minimum the glucose utilization was at the maximum and vice versa

It should never be forgotten that though curtailment of diet is necessary to lower the metabolic activities, the patient should be given enough food to supply him with his minimum requirements and to keep him in proper health otherwise the patient will draw upon his own body protein and fat and this state of affairs if continued for a long time may result in disaster

According to the old principle of treatment of diabetes by diet a high protein diet was usually given We know now that this method of treatment is not without its danger as acidosis and coma (which are dangerous complications) will often be a direct result of this method of treatment *Protein yields not only a large percentage of* glucose (58 per cent) but also a high percentage of acids capable of causing acidosis The increased metabolism and the increased nitrogen output in the urine observed under the old methods of treatment was due to the large nitrogen content *of the diabetic diet*

Several eminent physicians having made extensive studies have founded different methods of dietetic treatment *which are named after them* It is not necessary to go into them in detail but a brief outline of some of them would not be out of place

Allen's treatment—Founded by Frederic M Allen of America who may be said to have revolutionized the treatment of diabetes in his time by introducing his system of starvation treatment

This method of treatment was very widely used at one time but owing to the tediousness of the course the majority of the patients could not be induced to continue it for any length of time and so the ultimate results were often unsatisfactory This method of treatment is not much in use now

Allen's treatment was based on experimental observations on dogs which were made diabetic by the removal of part of the pancreas Allen found that the fate of these dogs as to recovery or death depended on the subsequent feeding they were subjected to If ordinary diet was given the animals died within a short time but if a carefully restricted diet was given life could be indefinitely prolonged

Graham's treatment—George Graham of St Bartholomew's Hospital in London working separately also came to the same conclusion as Allen Essentially the principles of treatment in the two systems are the same differing only in minor details This treatment is generally known as Graham's Ladder Diet

Joslin's treatment—Dr Joslin of America in dealing with recent cases of diabetes adopts the following line of treatment —

(1) The patient is put on a diet containing about 20 calories per kilo of body weight with carbohydrate at 100 to 130 grammes protein 50 to 60 grammes and fat between 60 and 80 grammes

(2) He is given 5 units of insulin before each meal if his urine shows at that time a red or yellow reduction with Benedict's test

As soon as the glycosuria diminishes the total calories are increased by gradual addition of carbohydrate protein and fat in proper proportions The increase of carbohydrate above 120 grammes should be done cautiously As soon as the

The 'line ration' scheme of Lawrence.—Lawrence introduced this system of measurement of diabetic diet in 1925 which has simplified the process of calculation both from the point of view of the doctor and the patient. By means of this simple yet varied diet scheme the busy practitioner is enabled to treat cases of diabetes without elaborate calculation of diet and food values and the diabetic patient is also able to vary his food to suit his taste. This form of dietetic treatment however has not found much favour among doctors and patients in this country, the chief reason being that the nature of the food taken varies so widely in the different parts of the country (according to race, religion, etc.) that no form of fixed diet scale appears to be suitable.

The practical method of the scheme is as follows :—

Each black line in the chart represents 10 grammes of carbohydrates and each red line represents 7½ protein and 15 grammes of fat. One line ration is a complete line and consists of one black and one red portion and has a caloric value of 210, so that to get the total number of line of rations allowed to the patient one has to divide the total caloric requirement of the patient by 210. Any black portion can be added to any red portion to make one ration but two black portions or two red portions must not be combined to make a ration.

High carbohydrate diet

During the last few years there has been an increasing tendency to treat cases of diabetes with a much higher allowance of carbohydrates than has hitherto been done. As a matter of fact the type of diet as advocated by Sansum, Geylin and others differs very little from the normal diet. The principle underlying this system of treatment appears to be based on the idea that increased carbohydrate intake under certain conditions stimulate the islet cells of

the pancreas to increased activity whereas a very low carbohydrate diet lowers the tolerance of carbohydrates.

The consensus of the present day opinion is that if a diabetic patient is given less carbohydrate than his real tolerance allows the carbohydrate tolerance will gradually fall through disuse It is also a recognized fact that once the carbohydrate content of the diabetic patient s diet is lowered to an extreme degree it is very difficult to raise it again

The author s clinical experience has been that it is *easier to get good results with an untreated diabetic than* one who has been rigidly dieted before Sweeney has definitely stated that there is a decrease in the patient s tolerance after a fat diet or starvation but an *increased* tolerance after a high carbohydrate diet

The tendency of the present day treatment of diabetes mellitus thus appears to be to give a high carbohydrate but *at the same time a low fat and a low caloric diet* The work of Rabinowitch of Montreal deserves special mention in this connection Rabinowitch has definitely shown by experiments carried on for over four years that patients previously on a low carbohydrate high fat and a high caloric diet sometimes require less insulin when their diet is changed to the high carbohydrate low fat and low caloric diet

Eason and Lyon (*Lancet* 1933) have confirmed Rabinowitch s findings and are of *opinion that if the total calories* are reduced by fat restrictions the dose of insulin may be reduced although the carbohydrate in the diet is doubled

Author s Formula for the Calculation of Diabetic Diet

In order to ascertain the amount of various foodstuffs required by a diabetic individual various formulæ have from time to time appeared The author has devised a

simple but proportionate formula to calculate a diabetic diet under basal conditions resting on the assumption that a diabetic requires 30 calories per kilo of body weight at rest or with very light work The weight of the patient in kilogrammes multiplied by 30 gives us the number of calories he requires (1 kilo = 2 2 lbs) This total caloric requirement divided by 15 gives the amount of fat the individual requires in grammes the same divided by 15 gives the amount of carbohydrate in grammes and when divided by 30 gives the amount of protein in grammes

Or

$\frac{\text{Calories required}}{15}$ *fat* in grammes

$\frac{\text{Calories required}}{15}$ – *carbohydrate* in grammes

$\frac{\text{Calories required}}{30}$ – *protein* in grammes

Let us take a concrete example

A diabetic individual weighing 70 kilos (11 stone) will require the following diet —

His caloric requirement at rest or light work would approximately be $70 \times 30 = 2100$

$\frac{2100}{15}$ 140 would be the approximate amount of *FAT* required in grammes

$\frac{2100}{15}$ 140 would be the approximate amount of CARBOHYDRATE in grammes

$\frac{2100}{30}$ 0 would be the approximate amount of *PROTEIN* in grammes

The number of grammes of fat carbohydrate and protein being thus ascertained the patient's diet is framed by the use of food tables (*see* Appendix II)

For the convenience of general practitioners three sets of diet suitable for a diabetic patient weighing about 70 kilos and having the approximate food values as detailed above are appended below —

Diet No I—Suitable for a European or an Anglo Indian

Diet No II—Suitable for an Indian on mixed diet

Diet No III—Suitable for an Indian on purely vegetarian diet

Diet No I

Foodstuffs	Quantity
Breakfast—	
Tea with milk ½ oz (without sugar)	1 or 2 cups
Bread	1 oz
Butter	¼ oz
Egg	1 only
Bacon	1 oz
Tomatoes	2 oz
Lunch—	
Beef tea or Bovril	8 oz
Green vegetables	8 oz
Lean meat (Mutton)	2 oz
Ham	2 oz
Bread	2 oz
Grapefruit	2 oz
Coffee (without sugar) with milk [illegible] oz	1 or 2 cups
Afternoon tea—	
Bread	1 oz
Butter	¼ oz
Egg	1 only
Tea with milk [illegible] oz (without sugar)	1 or 2 cups
Dinner—	
Clear soup	8 oz
Lean meat (mutton)	4 oz
Green vegetables	8 oz
Bread	2 oz
Apple	4 oz
Coffee (without sugar) with milk ½ oz	1 or 2 cups
Custard: Egg	1
Custard: Milk	4 oz
Custard: Saccharine	
Ghee or Butter for cooking	2 oz

Diet No II

Foodstuffs	Quantity
Early tea—	
Tea (without sugar) with milk 1 oz	1 or 2 cups
Bread	1 oz
Butter	¼ oz
Eggs	2
Breakfast—	
Atta Chapattis	2 oz
Green vegetables	8 oz
Fish (or meat)	3 oz
Dahi (unsweetened)	4 oz
Afternoon tea—	
Tea (without sugar) with milk 1 oz	1 or 2 cups
Bread	1 oz
Butter	¼ oz
Boiled vegetables	4 oz
Cocoanut kernel	2 oz
Dinner—	
Atta Chapattis	2 oz
Green vegetables	8 oz
Fish (or meat)	3 oz
Milk (1 cup)	6 oz
Ghee or butter (for cooking)	2¼ oz

Diet No III

Foodstuffs	Quantity
Morning—	
Milk	8 oz
Almonds or Pistachios	2 oz
Noon—	
Atta Chapattis	2 oz
Dal	½ oz
Green vegetables	8 oz
Dahi (unsweetened)	4 oz

Foodstuff	Quantity
Afternoon—	
Chhanna	2 oz
Cocoanut kernel	2 oz
Boiled vegetables	4 oz
Dahi (unsweetened) made into Ghol	4 oz
Night—	
Loochies or Paratas	2 oz
Dal	½ oz
Green vegetables	8 oz
Chhanna	2 oz
Ghee or butter (for cooking)	1 oz

Tea may be taken without sugar if desired

The patient is put on one of these diets for a week The total quantity of sugar excreted in 24 hours is estimated daily and this is subtracted from the available glucose in the diet * This figure will roughly indicate the patient s tolerance for sugar

On a diet calculated as above the average diabetic patient of the mild type usually becomes sugar free in four days and the blood sugar comes down to normal in about a week s time *If however the patient does not become aglycosuric or maintain the blood sugar at the normal level on such diet insulin treatment is usually indicated*

It should be remembered also that the diet outlined above allowing as it does only 30 calories per kilo of the patient s body weight should be considered to be only a *basal* diet i e it is enough for an average patient at rest

* This includes as already stated 58 per cent of glucose derived from the protein and 10 per cent from the fat in addition to 100 per cent from the carbohydrate in the diet

The total available glucose in the diet mentioned above would thus be as follows —

10% of 140 gm of fat	—	14 gm of available glucose
100% of 140 gm of carbohydrate	—	140 „ „
58% of 70 gm of protein		40 „
Total	—	194

The total *glucose value* of the diet is therefore roughly 194 grammes

but is insufficient for a person having to carry on his daily work and it is necessary that after the patient becomes sugar free and the blood-sugar comes down to normal, the carbohydrate content of the diet should gradually be increased (*keeping the protein and the fat content constant as far as possible*) so that the caloric value of the diet is gradually raised to about 35 calories per kilo of the body weight and thus for all practical purposes should be enough to maintain an average person doing ordinary work (*maintenance diet*). The addition of carbohydrates in the diet should however be done gradually 10 grammes each time allowing a period of 5 or 6 days in between to watch the effect.

For a rough and ready guidance to patients and to enable them to make suitable additions of carbohydrates to their diets as stated above a diet list is appended. As each of the foodstuffs given in the table below contains *approximately* 10 grammes of carbohydrate in the quantity noted against each item the patients get a fairly good choice for selection according to their taste and requirement.

TABLE IV *

Foods containing approximately 10 grammes of carbohydrate in quantities noted against each

Food	oz	Food	oz
Cereal Products—		Sago	[illegible]
Bread white	[illegible]	*Sooji*	[illegible]
(toasted)	[illegible]	Wheat flour (Atta or Maida)	
Barley	[illegible]	*Milk and Milk Products*—	
Beans	[illegible]	*Dahi* (unsweetened	[illegible]
Maize	[illegible]	Milk	[illegible]
Oatmeal	[illegible]	Powdered milk	[illegible]

* To weigh fractional portions of an ounce given in the following table may sometimes present difficulties but the following rough scale of weights with four anna bits may often be found handy and useful. Thus

3 four anna bits will approximately weigh 1 3 oz
4 „ 2 5 oz
5 „ 1 2 oz
[illegible] „ „ 2 3 oz
8 „ „ 3 4 oz

Foods containing approximately 10 grammes of carbohydrate in quantities noted against each—(contd)

Food	oz	Food	oz
Vegetables—		*Fruits*—	
Carrot	4	Apples	2 [illegible]
Green vegetables (average)	7	Guava	3
Green mango	4	Papaya	3
Green peas	2	Pineapple	3
Mankachu	2	Pumelo	3 [illegible]
Onion	3	Orange	4
Plantain (green)	2 [illegible]	*Nuts*—	
Potatoes	2	Chestnuts	1
Red pumpkin (*kumra*)	5	*Miscellaneous*—	
Raddish	5	*Force*	[illegible]
Tomatoes	8	Grape nuts	[illegible]
Turnip	5	Horlicks	[illegible]
		Ovaltine	¾
		Shredded wheat	[illegible]

Monotony of diets

Diabetic patients often complain of the sameness or monotony of their daily diet A wise and intelligent person may with a little care and judgment greatly minimize this disadvantage All that is necessary is to substitute one food occasionally for another with more or less similar food values This can be done easily by consulting the food tables given in the appendix and taking different quantities of other food stuffs containing the same amount of carbohydrate or protein

To enable patients to select such *equivalent* foods a list is appended below keeping 1 oz of bread, containing about 16 gramms of carbohydrate per ounce as a standard for comparison with other carbohydrate foods The list indicates the approximate quantity in ounces of some of the other carbohydrate foods which can be exchanged for each ounce of bread If only half an ounce of bread is required to be exchanged the quantity given in the list has to be halved

TABLE V

Approximately Equivalent Foods

Food	oz
Starchy foods—	
Bread	about 1
Barley	¾
**Chira* (beaten rice)	¾
Cream cracker biscuits	1
Corn flour	⅔
Force	⅔
**Kho* (fried paddy)	¾
Macaroni	¾
Maize (*makai*)	¾
Muri (Puffed rice)	¾
Oatmeal	¾
*Rice	⅔
Sago	⅔
Shredded wheat	⅔
Sooji	1
Wheat flour (*maida* or *atta*)	¾
Vegetables—	
Beet	4
Jack fruit seed	1½
Mango (green)	6
Mankachu	3
Onions	5
Peas (green)	3
Potatoes	3
Fruits—	
Apple	4
Banana	2½
Guava	5
Mango (ripe)	3
Orange	6
Papaya	4½
Pineapple	5
Pumelo	5½
Nuts—	
Chestnuts	1½
Milk and Milk Products—	
Milk	11
Horlicks	¾
Ovaltine	1
Miscellaneous—	
Sandwich (chicken)	1½

* Foods marked with asterisks should not be taken [illegible]

CHAPTER X

INSULIN TREATMENT

THERE is no doubt that the discovery of insulin has completely changed both the outlook and the treatment of diabetes mellitus specially of the severer type It has certainly helped to save many lives but at the same time a note of warning should be sounded regarding its exact place in the treatment of diabetes mellitus about which so much misconception still exists Joslin very aptly says *Insulin is a remedy primarily for the wise and not for the foolish be they patients or doctors* One should never forget that insulin has its uses and abuses its potencies as well as its limitations and the misconception that unfortunately prevails *viz* that by resort to this treatment one is at liberty to have practically unlimited diet should be combated and condemned The patient undergoing insulin treatment should be clearly made to understand that insulin is only a valuable adjunct to the dietetic treatment and that it can in no sense be considered to be a substitute for the other and that to get the full benefit of insulin treatment there must be a more or less constant relationship between the dosage of insulin and the quantity of the diet allowed in individual cases Under no circumstances should insulin be given in large doses merely to satisfy the [illegible] is propensities of the patient The unfortunate [illegible] prevails in some quarters of employing this [illegible] in order to allow the patient [illegible] satisfaction controlled luxuries in[illegible] inst the in the treatment and sl[illegible] ly disc method of treatment [illegible] increa and weight of the pati[illegible] for a does not take into cons[illegible] e of all which is thereby [illegible]

necessary increase in the metabolic activities of the patient brought on by this method of treatment is apt to cause further damage to the already damaged pancreas with the prospect of its being eventually destroyed thus necessitating the use of continually increasing dosage of insulin. Lawrence has very rightly said that this method is like adding another cylinder and extra horse power to a damaged motor thereby running the machine too fast for the damaged part and ultimately wearing it out altogether so that more and more horse power has to be added if the machine is to be kept going at all.

Another misconception unfortunately prevalent even today is that once insulin is taken it has to be continued for a life time. The pity of it is that such misconception is responsible for driving many cases into the arms of quacks and dealers in secret medicines resulting in unnecessary suffering and hardship often ending in disaster. It should be made clear once for all that insulin never generates or develops a habit like the narcotic drugs and the literature is very full of evidence that when insulin is used judiciously the carbohydrate tolerance of the patient improves so considerably that the dose of insulin may gradually be reduced until it may ultimately be stopped.

Insulin Treatment

The principle underlying the treatment of diabetes by insulin is mainly this that those diabetics who can remain aglycosuric maintaining a normal blood sugar level and living a comfortable life by a quantitative restriction of diet alone do not ordinarily require insulin but those who cannot avoid glycosuria and hyperglycaemia on the maintenance diet (described in the previous chapter) do need it.

It has been stated before that the ideal aim in the treatment of diabetes mellitus is to keep the fasting level of blood sugar within normal limits. The urine may become sugar free but the blood sugar may still be 40 to 50 per cent

higher than normal There are many practitioners who give insulin injections, taking the urinary sugar as the only guide They usually stop the injections when the urine becomes sugar free, for fear of inducing hypoglycaemia, but the blood being still in the hyperglycaemic state, the pancreas does not get sufficient rest and so the ultimate result has often proved to be unsatisfactory The ideal *method of treatment would therefore*, be to take as much strain out of the pancreas as practicable by trying to keep the blood sugar level as near normal as possible

For helping practitioners in mofussil towns and villages to carry out insulin treatment by regular blood sugar tests, the author has devised a simplified method for the estimation of sugar *in the blood the details of which are given* in Chapter XIV

Insulin treatment without regular blood sugar tests

When one has to depend upon the urinary sugar as the sole guide the following procedure may be found useful

Calculate a diet for the patient according to his weight following the instructions given in the previous chapter Divide this diet into 3 or 4 meals Estimate how much sugar the patient passes 3 hours after each meal

On the first day of treatment with insulin give a small dose 15 to 30 minutes before breakfast and see how far the urinary sugar goes down especially in the two specimens 3 hours after breakfast and 3 hours after dinner If the sugar falls after breakfast but remains the same after dinner it *shows that either the dose of insulin was* insufficient or its effect did not last long In that case, the dose of insulin should be increased say by 4 units Now, if by increasing the the dose of insulin the specimen after breakfast becomes sugar free *but the specimen after dinner* still contains sugar the dose should be kept constant for the next two days in order to see if the evening urine becomes ultimately sugar free If it does not, there *are* two alternatives the first being to slightly increase the dose of insulin still further and the other being to give a second injection of a small dose of insulin in the afternoon say before tea

When in this way the urine becomes free from sugar during the whole day for three or four days running, the carbohydrate in the diet may be increased concurrently with the dose of insulin till the required quantity of food sufficient for ordinary work is reached *Thus by care*

Insulin is a complex protein derivative probably of the nature of a proteose and as such is likely to cause urticarial forms of allergy specially in diabetic patients who according to many workers have a peculiar predi position to such reactions

It appears that improvement in the mode of prepara tion of insulin has to some extent helped to lessen the allergic manifestations but in the more hypersensitive diabetic patients even crystalline insulin has been found to bring on undesirable and sometimes well marked anaphy lactic reactions

It is a significant fact however that diabetic patients who are extremely sensitive to one brand or preparation of insulin often become much less so when the brand is changed Such a simple measure in such apparently grave *crisis must be considered as a circumstance of great favour to most diabetic patients as otherwise one would either* have to give up insulin treatment or do it at great risk and discomfort to the patient Grave forms of insulin allergy severe enough to embarrass insulin therapy are rare

Symptoms of insulin anaphylaxis—The symptoms of insulin anaphylaxis usually encountered begin as a rule within a short time of the injection sometimes within five minutes A small or fair sized weal usually appears at the site of the injection followed almost immediately by urti carial rashes throughout the body This causes an uncon trollable generalized itching which lasts for an hour or more Grave constitutional symptoms such as nausea vomiting cardiac distress (as encountered in one case) have been for tunately rare among other cases under the author's obser vation

Method of Desensitization—*The* usual method is to begin with an intradermal injection of a minute dose of *diluted insulin followed by* gradually *increasing doses* given at different intervals If however allergic reactions appear the dose should be reduced and a start should be

made from the dose previous to the one which caused the reaction. Soluble crystalline insulin should preferably be used.

The procedure followed by the author is as follows:— Give an initial dose of 0.001 ($\frac{1}{1000}$) units of insulin intradermally and follow it up with another three injections of 0.002 ($\frac{1}{500}$) units, 0.004 ($\frac{1}{250}$) units and 0.008 ($\frac{1}{125}$) units of insulin in the course of the day. If no reaction occurs on the first day, dosages of 0.01 ($\frac{1}{100}$) units, 0.02 ($\frac{1}{50}$), 0.04 ($\frac{1}{25}$), 0.1 ($\frac{1}{10}$) units should be given the next day. If still no reactions occur, dosages of 0.2, 0.5, 1 and 2 units should be given on the third day. The dose should then be gradually increased. In a certain number of cases the author has tried 8 injections all in the course of one day with no untoward event and with good results.

Dilution of insulin for purposes of desensitisation.— 5 units of crystalline insulin should be diluted with 50 c.c. of sterile normal saline. Each c.c. of this diluted solution will thus contain 0.1 unit of insulin. Mix 1 c.c. of this diluted insulin solution with 9 c.c. of sterile normal saline. 0.1 c.c. of this solution will thus contain 0.001 or ($\frac{1}{1000}$) units of insulin.

Desensitisation with Histamine.—Repeated injections of small doses of histamine phosphate also cause a progressive decrease in the insulin allergic reactions.

The new synthetic anti-histamine drug Benadryl has also been used in cases of insulin allergy in the Mayo clinic with encouraging results.

Insulin Resistance

It is an usual finding that cases of diabetes on similar diet scales require more or less an uniform amount of insulin to keep them under control. This however is not true in all cases; in some larger doses have to be given and

even then the ultimate results are not satisfactory These latter cases are usually termed resistant or refractory cases The opinion of the author however is that if a proper and careful adjustment of the diet and the dosage of insulin is made in these cases they usually react favourably though they may require larger dosages temporarily The causes for the temporary higher requirement of the amount of insulin according to the author are usually sepsis nervous excitement and excessive worry which should be removed as far as possible

Indications for insulin treatment

(1) Obviously in all cases of true diabetes mellitus where there is pronounced hyperglycæmia or marked glycosuria (with or without ketosis) the symptoms are usually so marked that no difficulty is experienced in coming to the conclusion that insulin treatment is indicated

(2) In all cases of diabetes mellitus with complications such as coma tuberculosis infections etc insulin is indicated

(3) Cases of pronounced diabetes mellitus in children or young men below 35 call for insulin treatment

(4) Mild cases of diabetes mellitus with vague symptoms attributable to diabetes where a careful dietetic regime has failed to remove glycosuria or reduce hyperglycæmia say below 0 14 per cent also point to insulin treatment If these cases are neglected on the ground of the vagueness of symptoms they are likely to develop definite symptoms or lead to complications later on such as (1) neuritis (2) carbuncles cellulitis gangrene etc (3) blindness (4) tuberculosis

Dosage of insulin

It should be stated at the very outset that unlike most drugs insulin has no fixed dosages and that there is also no hard and fast rule regarding the same the dose may vary

in different cases according to the severity of the disease, the complications, the diet prescribed and various other factors. The author is able to cite many instances where insulin was wrongly and unwisely discredited owing to the use of improper or inadequate dosage; those very cases on proper adjustment of the dose gave very good results. It is essential therefore that the correct dose of insulin should be worked out in every case individually.

The amount of glucose utilized per unit of insulin is different in different cases and even varies under changing conditions in the same case. It has however been roughly estimated that one unit of insulin usually causes 1 to 2 grammes of carbohydrates to be utilized in a moderately severe case of diabetes. In a milder case the carbohydrate utilization per unit of insulin is somewhat greater than this. This fact should be taken into consideration in selecting the proper dose for a given patient. As a method of ready reckoning it may be stated that the total amount of available glucose calculated from the patient's diet *minus* the total amount of glucose passed in the urine will roughly indicate the carbohydrate tolerance of the patient, and the amount of glucose which is over the limit of tolerance (i.e. the amount excreted in the urine) must be covered by an adequate dose of insulin calculated according to the method given below.

Rough and ready method of calculating insulin dosage.
Calculate the glucose value of the patient's diet according to the instructions already given on page 96; calculate the total sugar excretion in grammes in 24 hours.

E.g.:
Total glucose value in diet 194 gms.
Total sugar excretion:
Total quantity of 24 hour urine 1500 c.c. (50 oz.)
Glucose present 4%
Total sugar excretion (24 hours) $= \frac{1500 \times 4}{100} = 60$ gms.

194 − 60 = 134 grammes will therefore roughly indicate the tolerance of the patient.

The 60 grammes of glucose which is over the limit of the patient s tolerance will *have to be covered by insulin* injections in the ratio of 1 unit of insulin for every 2 *grammes of glucose as mentioned* before

The dose of insulin to be injected will thus roughly be $\frac{60}{2} = 30$ units

If however the calculated *dose of insulin required* much exceeds this dose it is safer to divide the dose into a larger *and smaller fraction* and give *it in two injections* instead of one The larger dose should be given 20 minutes to half an hour before breakfast and the smaller dose given 8 hours later i e before tea

If the case is more severe and requires much bigger doses gradual and cautious increase in the dosages has to be made

It should be pointed out however that as already stated the method given above is only intended to be a rough and ready guide as to the approximate dose of insulin required for a given patient The degree of fasting hyper glycaemia present must always be taken into account and suitable adjustments of the insulin dosages made accordingly whenever necessary

In some of the very severe cases requiring very big doses of insulin the injection has sometimes to be given more than twice daily and even then it has been found difficult to maintain a steady level of blood sugar near about the normal range throughout 24 hours In such cases the use of the new insulin compound Protamine Zinc Insulin has often been found to be of great advantage and in some cases it has been found possible to keep even severe diabetics in good health even with one injection a day The *details are described in a previous chapter* (Chapter II)

Insulin Mixture—It has already been stated that the action of protamine zinc insulin is very slow and gradual and if an injection is *given before breakfast* as is usually done it would not be able to effectively control the post

breakfast hyperglycaemia and glycosuria in a moderately severe case of diabetes. For the same reason it does not also effectively control the rapidly increasing hyperglycaemia following a high carbohydrate diet or in cases of severity with complications such as acidosis etc. In such cases a mixture of soluble insulin (for the quick control of the post-breakfast hyperglycaemia) and protamine zinc insulin (for its slow and prolonged action) is advocated and is found to be of great advantage in effectively controlling the hyperglycaemia in severe cases of diabetes. No hard and fast rule can, however, be laid down as regards the proportion and the dosage of each of the two kinds of insulin to be used, as much would naturally depend on the individual cases and has to be varied even in the same case according to the results obtained.

As a practical measure it may be noted that in drawing the two insulin solutions in the same syringe, the soluble *insulin should be drawn in the syringe first and then the* requisite amount of protamine zinc insulin drawn and *mixed in the syringe. If the process is reversed, i.e., if the* buffered protamine zinc insulin is drawn first, there is risk *of inactivation of the acid soluble insulin if any protamine* zinc insulin be introduced into the phial.

Contraindications for insulin treatment

(1) All cases of renal glycosuria or glycosuria of non-diabetic origin. Very careful diagnosis by the methods suggested before should be made.

(2) Certain cardiac diseases. It sometimes requires very careful judgment on the part of the physician to decide in cases of diabetes complicated with cardiac diseases whether to give insulin or not.

The experience of the author goes to show that insulin may prove to be very dangerous in cases of marked myocardial degeneration and in angina pectoris. Before deciding to give insulin to any patient, it is the duty of the physician

to examine the heart carefully and to enquire if the patient has suffered from anginal attacks

In such cases where it is found that insulin treatment is the only chance of saving the life of the patient the physician has to go very carefully and feel his way at every step One of the main points which he should bear in mind is that he should never attempt to make the patient sugar free If hypoglycæmia develops in these cases it may prove fatal

It may however be stated that ordinary valvular diseases of the heart may be treated with insulin with a fair margin of safety but the physician must also try to prevent hypoglycæmia as far as possible

A few general hints on insulin treatment

(1) Always aim at keeping the blood sugar level as near the normal limit as possible

(2) The selection of the proper dose and the spacing of insulin injections are the difficult parts of the treatment Too small a dose or one given at too long an interval often does not produce the desired effect a dose too big or given too soon after the first injection often produces nasty reactions

(3) There must be a definite and close relationship between the dose of insulin and the sugar value of the diet given according to the tolerance of the patient

(4) The decrease of hyperglycæmia and glycosuria should be carefully noted at every step and the dose of insulin regulated accordingly

(5) Injections of soluble insulin should preferably be given fifteen minutes or half an hour before meals Injections of Protamine Zinc insulin may be given 45 minutes to one hour before meals

(6) All forms of hard or strenuous exercises should be strictly forbidden for at least 3 or 4 hours after insulin injection

(7) Even a minor infection upsets the sugar tolerance of the diabetic patient This should be remembered and an increase in the usual dose should be made if the patient suddenly develops such an infection In major infections much increase in the dose is necessary In patients suffering from acute infections such as tonsillitis bronchitis or pneumonia always guard against acidosis by proper adjustment of the diet and the dose of insulin

(8) If possible all cases of diabetes undergoing surgical operation urgent or non urgent should be made sugar and ketone free and the blood sugar brought down to normal

(9) In diabetic pregnant women sudden variations in sugar tolerance may take place leading to severe acidosis Insulin treatment should be commenced on the slightest indication of acidosis

(10) It should be remembered that in diabetes complicated with tuberculosis of the lungs insulin plays an important part because with its aid a satisfactory diet which is essential to maintain the resistance and the body weight of the patient can be given

(11) Insulin has also been found to be of help in the treatment of a few cases of acidosis of non diabetic origin such as hyperemesis gravidarum and surgical shock of non diabetic individuals In these cases sufficient glucose must be given to the patient after insulin injection to prevent any chance of hypoglycaemia

(12) Small doses of insulin followed by glucose has also been found to be useful in a few cases of malnutrition sprue etc

Vitamins in Diabetes

Vitamin B_1

Thiamin chloride ($C_{12}H_{17}N_4SOCl\ HCl$)
Water soluble and partially thermo labile

Sources—Germ and pericarp of cereals enriched bread yeasts and legume seeds, yolk of eggs liver, meat particularly pork certain fruits and vegetables

Vitamin B_1 is relatively resistant to heat but is destroyed by prolonged boiling

Action on carbohydrate metabolism—It has definitely been shown that in thiamin deficiency the carbohydrate tolerance is definitely lowered Thiamin catalyzes the trans formation of pyruvic acid (an intermediate product in the oxidation of carbohydrates) and thus helps the carbohydrate metabolism Deficiency of thiamin therefore interferes with the normal metabolic interplay between glycogen lactic and pyruvic acid In normal carbohydrate meta bolism thiamin is believed to act as a co enzyme and helps in the enzymic activation of the oxidation of pyruvic acid and hence in thiamin deficiency the carbohydrate meta bolism stops with the formation of pyruvic acid which thus accumulates in the blood

Action in diabetes—The role of vitamin B_1 in human diabetes has been a subject of controversy for some time past The author has been engaged in this study for some years and from the results of the experiments hitherto obtained he is in a position to say that in a good number of these cases a definite improvement in the carbohydrate metabolism frequently follows an intensive vitamin B_1 therapy along with an improvement in the general condition of the patient The improvement or otherwise of a diabetic patient as a consequence of vitamin B_1 therapy of course depends on whether there is vitamin B_1 deficiency or not The symptoms of thiamin deficiency are rather vague but the main specific symptoms were anorexia gastro-intestinal hypotonia, constipation indefinite pains paraesthesia etc

In cases of thiamin deficiency a marked improvement in the general health of the patient quickly occurs as a result of vitamin B_1 therapy

Vitamin C

Ascorbic or Cevitamic acid ($C_6H_8O_6$)

Water soluble and heat labile

Sources—Fresh fruits and vegetables particularly lemons pumelo (Batabi lebu) and other citrous fruits tomatoes etc non pasteurized cow s milk etc

Action on Diabetes—It has been shown that in uncomplicated cases of diabetes whose vitamin C intake has been adequate the fasting level of plasma ascorbic acid is normal The administration of ascorbic acid in these cases had no effect on the progress of the disease Most observers do not support the idea of any specific relationship of vitamin C to diabetes

The author studied the effect of ascorbic acid in diabetic patients of various grades of severity and is of opinion that administration of vitamin C even in large doses does not affect the severity of the diabetic condition

In recent studies on experimental diabetes caused by Alloxan it has also been proved that injections of ascorbic acid did not protect animals against Alloxan and did not in any way deflect the course of Alloxan diabetes

CHAPTER XI

SOME OF THE DANGERS AND COMPLICATIONS OF DIABI AND THEIR TREATMENT

The most serious dangers which threaten a dia patient are coma, gangrene, carbuncles, acute infec severe nephritis, tuberculosis, etc

Diabetic acidosis and Coma—We know tha diabetes not only the carbohydrate metabolism but also of protein and fat are affected We also know that normal carbohydrate combustion in the system is al accompanied by a defective fat metabolism, because, as been stated before, "fat in the food burns in the flam carbohydrates" and that without it "the fire smokes"

For the proper utilization of fat, the simultan oxidation of a definite amount of carbohydrate is esse and if the system is unable to burn the requisite am of glucose, a portion of the fat is incompletely oxidized as a result ketone bodies are formed and accumulate the blood The system tries to get rid of this exces ketone production in two ways —

(1) By excretion in the urine as free acid, and
(2) By neutralization of the acid bodies and excretion of the resultant bases in the ur

When the production of the acid bodies are excess the neutralization is effected by withdrawal of fixed ba chiefly, sodium and potassium, from the blood and tiss This naturally results in the depletion of the alkali rese and in a reduction in the bases of the blood A lowe concentration, not only of the total salts, but also of total electrolyte in the body fluid thus results

The excretion of large amounts of fluids, in the atten to remove these acid bodies from the blood, naturally resu in dehydration and haemo-concentration, as well as a seve

depletion of the bases and of the chloride content The alkali reserve of the body is also depleted for the same reason resulting in the reduction of the carbon dioxide combining power of the plasma

Causes of Diabetic Coma

The usual causes of severe acidosis and coma are (1) sudden dietetic unbalance (2) sudden stoppage of insulin and (3) infections These are often preventable and every patient should be pre warned against them They should particularly be warned against the dangers of neglecting an infection of any kind however slight it may apparently appear to be at the beginning It should always be remembered that infection aggravates the diabetic condition suddenly and often precipitates coma

Diagnosis—The diagnosis of severe acidosis and diabetic coma may often be made clinically with a fair degree of accuracy if the patient is known to be a diabetic Among the characteristic points in the *bedside* diagnosis of diabetic acidosis and coma the following may be noted —

(1) Headache drowsiness or actual coma
(2) Anorexia vomiting abdominal pain
(3) *Skin*—very dry due to severe dehydration
(4) *Respiration*—Characteristic deep and slow abdominal type of breathing (air hunger)
(5) *Eyes*—Low tension of the eye balls This is a very characteristic sign and is often diagnostic
(6) Pulse—low tension and a high rate
(7) Blood pressure—low
(8) Breath—Characteristic aromatic (acetone) odour

Among the chief laboratory findings of importance in a case of diabetic acidosis and coma the following are of importance and should be ascertained whenever possible —

Blood

Blood sugar—This is invariably very high but there seems to be no definite relationship between the degree of

hyperglycemia and the depth of the coma In one of the author s cases with a blood sugar of 1 08 per cent (1080 mgs) the patient could still be roused and he recovered ultimately

Leucocytosis—This is usually *present and may be very* high in some cases

Serum potassium concentration—According to recent observations by the author it appears that the maintenance of normal concentration of the serum potassium has a very important bearing on the prognosis of severe diabetic acidosis and coma A progressive lowering in the concentration of serum potassium has been observed in some cases of diabetic coma and this may cause death if the depletion is severe inspite of the blood sugar level and the plasma CO being more or less within normal limits

*A severe depletion of serum potassium is usually indi*cated by marked respiratory difficulty difficulty in swallowing and extreme muscular prostration

Carbon dioxide combining power of the plasma (alkali reserve)—In healthy individuals the plasma (at rest) contains 55 to 70 c c of CO_2 (bound as bi-carbonate) per 100 c c of plasma measured at 0°C and 760 m m pressure In bad cases of diabetic acidosis this figure is much less *(below 40 volumes per cent) and* in severe cases it may go down to 20 volumes or even less This test is usually done by the Van Slyke method

Carbon dioxide in alveolar air—Normally the carbon dioxide content in the alveolar air is about 5 per cent but may fall to 2 per cent or below in cases of diabetic coma The possibility of doing this test at the bed side is a further advantage of this method This is usually done by Friede*ricia s method* and *is* fairly simple

Urine—The urine besides containing large amounts of sugar invariably contains fair and large amounts of ketone bodies The determination of the total acidity of the urine

and the ammonia coefficient (i e, the relation between the urinary ammonia and the total nitrogen) often gives useful information particularly in adjudging the effect of the treatment

Differential Diagnosis—When however a patient is seen for the first time in an unconscious state and when the previous history of the case is unknown or not available it may often present difficulties in making a diagnosis of diabetic coma on the spot because the physician has to bear in mind some of the other causes of unconsciousness the noteworthy amongst them being hypoglycaemic coma uraemia cerebral haemorrhage and meningitis The following distinctive clinical features in each of the above individual conditions will however help in making the differential diagnosis easier

Hypoglycaemic Coma—

Onset—sudden
Respiration—shallow
Pulse—often irregular
Skin—moist
Eyes—tension normal Double vision at times
Tremor—present
Blood pressure—normal
Blood sugar—low
Urine sugar and Ketones—usually absent

Uraemic Coma

Onset—slow
Respiration—cheyne stokes type
Pulse—full and bounding
Skin—dry
Eyes—high tension of the eye balls
Muscular twitchings
Blood pressure—usually high
Urine—albumin casts R B C etc

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Skin—moist
Eyes—tension normal Double vision at times
Tremor—present
Blood pressure—normal
Blood sugar—low
Urine sugar and Ketones—usually absent

Uræmic Coma—

Onset—slow
Respiration—chyne stokes type
Pulse—full and bounding
Skin—dry
Eyes—high tension of the eye balls
Muscular twitchings
Blood pressure—usually high
Urine—albumin casts R B C etc

Cerebral hæmorrhage—

Onset—rapid
Respiration—stertorous usually foam-covered lips
Eyes—pupils dilated and unequal conjugate deviation
Unequal resistance of limbs in lifting
Blood pressure—high
Glycosuria may be present

Meningitis—

Onset—sudden
Respiration—rapid
Eyes—pupils dilated or unequal
Fever—present
Leucocytosis
Kerning s sign
Glycosuria may be present

It is thus essential that before starting vigorous treatment *proper diagnosis should carefully be made*

Treatment —It should be fully realized that a true case of diabetic coma is as much an emergency as a case of acute appendicitis or a spreading peritonitis and the treatment *should be prompt vigorous and thorough In the pre* insulin days the outlook for these cases was very gloomy *indeed almost every case proving fatal even with the best* possible help but with the advent of insulin there has been a complete change for the better so much so that with an early administration of insulin in suitable doses the recoveries are so frequent that they are no longer considered even worthy of record

The following main principles must be borne in mind in the treatment of a case of diabetic coma —

(1) That the cause of the ketosis (which leads to coma) is disordered fat metabolism which in its turn is due to defective sugar combustion and that if sufficient sugar can

be made to burn in the system the ketosis will disappear Thus the importance of giving insulin *early* and in *proper* doses according to the severity of the case is at once made manifest It should be noted that to give small doses of insulin in cases of true coma where much bigger doses are required is playing with the life of the patient and if the general practitioner who is called upon to see the case has no special experience or aptitude in the treatment of such cases he should give the patient a large dose of insulin with glucose and send him to hospital at once

(2) That the coma is often precipitated by an acute infection of some kind often causing profound toxæmia The septic focus should be determined and the source of the toxæmia should be eliminated if possible Insulin is rela tively ineffective in the presence of a severe toxæmia

(3) That in some bad cases of diabetic coma there is severe dehydration which is sometimes so marked as to cause a shrunken appearance of the patient simulating a case of cholera This is due to severe loss of fluid owing to previous polyuria and vomiting and sometimes causes a marked fall in the blood pressure low tension in the eye balls a feeble and thready pulse and a circulatory collapse and unless this condition is promptly treated by administer ing large quantities of fluid (intravenous or subcutaneous saline as the case may require) the patient dies of circula tory collapse from which insulin alone is unable to save him

(4) That the strain on the heart in patients suffering from diabetic coma is often considerable—the strain in volved in hyperpnœa alone being much too high and the heart experiences great difficulty in withstanding the demands made on it Every precaution must therefore be taken to protect the heart

Main points in the treatment of diabetic coma—

(1) *Care*—Keep the patient warm in charge of a trained nurse if possible

(2) *Insulin*.—Give insulin (soluble) *immediately on diagnosis in adequate doses* and repeat at intervals of 3 hours (or earlier in extreme cases) till there is clinical or laboratory evidence of improvement.

(3) *Fluids*.—Treat dehydration energetically by adequate administration of fluids. It should be remembered that *this procedure is as important as administration of insulin*.

(4) *Gastric Lavage*.—Remove gastric contents by a gentle lavage with warm normal saline: this procedure checks vomiting, prevents abdomenal distension and often relieves cardiac distress.

(5) *Enema*.—Relieve a distended rectum by enema.

(6) *Circulatory stimulants*.—In threatened circulatory collapse give Epinephrine in 0.5 to 1 c.c. doses. Ephedrine may be given in 25 to 50 mg doses if the blood pressure is rapidly falling. Treat other conditions according to circumstances.

(7) *Blood sugar*.—Do blood sugar tests as frequently as practicable to regulate insulin dosage.

(8) *Blood pressure*.—This should be taken frequently. Systolic pressure below 100 mg usually means bad prognosis.

(9) *Glucose*.—Vide infra.

(10) *Alkalies*.—Vide infra.

(11) *Septic Foci*.—The septic focus, if any, should be sought for and removed as much as possible.

The Position of Glucose Therapy in the Treatment of Diabetic Acidosis and Coma

Before going into the details of treatment a few words should be said regarding the real position of glucose therapy

in the treatment of diabetic coma, about which a good deal of controversy still exists. Taking the extreme views on the subject, we have Himsworth * on the one hand, who believes that the essential therapeutic agent in the treatment of diabetic intoxication is *glucose*—the fundamental idea being to give glucose, *glucose always* covered by the necessary amount of insulin—and not insulin covered, if necessary, by glucose as is the current practice. Joslin † on the other hand holds the opposite view. According to him there is no need of protecting the patient *against insulin* by the administration of glucose. It is better to concentrate on protecting the patient *with insulin* by watching changes in the blood and the urine sugars in order that the proper amount of insulin may be given.

According to some authorities, the method of procedure in the treatment of diabetic coma is the initial administration of insulin without glucose, because they argue that with the surplus sugar circulating in the blood, the giving of extra glucose is unnecessary. There are many others, however, who are definitely of opinion that glucose should always be given along with the insulin injection, because they argue that it is better to allow the hyperglycæmia to go on than to produce hypoglycæmia which is sometimes a dangerous complication in diabetic coma difficult to detect immediately.

Without going into the details of the controversy, the author is definitely of opinion that it is certainly a wiser policy to give glucose in suitable doses along with insulin injections. One of the great advantages of this method of treatment is that by following this plan, the average practitioner feels safer in giving large doses of insulin, *which is the one thing absolutely essential for the patient's recovery from coma*. Besides, when the ketosis is of a grave and perilous nature, the extra amount of glucose given will permit of heroic doses of insulin being administered. This

* *Lancet*, CCXXIII, 165.
† *Med. Clin. North Amer.*, XX, 829, 1937.

will ensure the prompt oxidation of a large amount of glucose in circulation and the improvement in the fat combustion thus effected will cause simultaneous and rapid reduction in the ketone bodies Against the argument that an unnecessary production of hyperglycæmia is caused through administration of glucose it may be said that it has been shown by experiments that a prolongation of hyperglycæmia does not in any way affect the recovery of the patient from diabetic coma if sufficient insulin is given to oxidize it Coma has been found to clear up even though hyperglycæmia is still present In one of the author s cases the patient had an uneventful recovery from coma even with a blood sugar of over 1 per cent The only point to remember is that the total amount of glucose administered must have a definite relationship to the total daily dose of insulin given and if glucose is given intravenously its strength should rarely exceed 10 per cent

Treatment of pre-comatose conditions—Here though the patient is usually very drowsy he can still be roused and made to swallow Circulatory collapse due to dehydration is usually less frequent and these cases are more easy to deal with

The general principles of treatment follow the lines outlined above

The bowels should be cleared and if there is vomiting a stomach wash should be given with a warm soda bicarb solution (3ii to one pint)

40 to 60 units of insulin should be given immediately followed by about 40 grammes of glucose by mouth either as glucose solution flavoured with lemon juice or in the shape of orange juice—(about 16 ounces of the juice) plenty of fluids should be given in the shape of water tea barley water and alkaline drinks The urine should be collected 2 hours after the injection and examined for sugar acetone and diacetic acid and if possible a sample of blood should be collected for estimation of blood sugar If the

blood sugar is still very high and the urine contains a fair amount of sugar acetone and diacetic acid a similar dose of insulin should be given followed by some more glucose The dose of insulin will in this way have to be regulated very cautiously according to the improvement or otherwise in the patient s condition verified by urine and blood sugar tests As the condition improves the dose of insulin will have to be decreased and the interval between the injections increased till the blood sugar comes down to below say 0 2 per cent and the acetone bodies disappear from the urine It is a wise thing not to allow the urine to become completely sugar free till the patient can be declared to be out of danger This is easily possible by a judicious adjustment of the dose the interval of insulin injections and the amount of sugar given to the patient It is unnecessary to add that the patient must be on a liquid diet chiefly consisting of carbohydrates

Treatment of complete coma —Though the main principles of the treatment are the same these cases present many difficulties owing to the number of complications present In these cases the patient is absolutely unconscious and hence cannot swallow Besides in some of the very severe cases there is usually marked dehydration and severe cardio-vascular collapse Treatment in such conditions requires much tact care and promptness on the part of the physician because insulin alone or insulin and glucose combined may fail to bring the patient round and unless prompt and energetic measures are properly taken these patients may die of circulatory failure in spite of having big doses of insulin To prevent circulatory collapse enough of fluids should be promptly given to replace the fluid lost in the tissues As a matter of fact the treatment of these cases should be more or less on the same lines as in cholera viz introduction of saline by the intravenous subcutaneous and the rectal route

The exact strength of the saline to be used for this purpose is a matter of opinion Some prefer hypertonic

saline solution for the first infusion, others use normal solution The author prefers to use the latter but combines glucose *with this, so that the strength of the* glucose in the solution becomes 10 per cent, as in the following formula —

Glucose (pure anhydrous)	60 grammes
Sodi chlor (pure)	5 „
Aqua	1 pint

The proportion of glucose in the above solution will be 3 grammes per ounce The glucose used in the preparation of this solution should be extra pure, of the anhydrous variety, *specially used for intravenous injections, and should* be properly sterilized

About 1½ pints of this solution containing about 90 grammes of glucose *should be given by the intravenous* route very slowly At least one hour should be taken to give the intravenous injection and the temperature of the fluid should be about 106°F Fifty units of insulin should be given subcutaneously or intravenously at the commencement of the intravenous glucose saline injection and another 40 units when half of the solution has been injected Some authorities *prefer to give 7 per cent gum acacia* solution in addition the idea being that it remains in the circulation better than the glucose saline alone Glucose and saline may also be given per rectum

If necessary, the above treatment may be repeated after 3 hours—the amount of fluid to be injected, the dose of insulin, etc, depending on the patient's condition and on *the result of blood and urine tests*

When, in this way, the patient recovers from coma—the dehydration becoming less marked and the patient being able to swallow—the fluid introduced intravenously should be regulated or stopped and the patient should be given glucose by the mouth The dose of insulin and the amount of glucose will of course have to be regulated

according to the condition of the patient till the patient sufficiently recovers and the acetone bodies disappear from the urine and remain absent on repeated examinations The patient may then be put on a gradually increasing diet chiefly consisting of carbohydrates The dose of insulin and the interval between the injections should also be accordingly regulated

Alkalies and Diabetic Acidosis

The use of alkalies in large doses used to be the standard treatment of acidosis and diabetic coma but at the present time there is diversity of opinion regarding the value of alkalies in such conditions An authority of the eminence of Joslin takes the view that alkalies in such cases are useless if not harmful His reasons may be summarized as follows —

(1) Groups of cases treated without alkalies give very much more satisfactory results than the group treated with alkalies

(2) When the alkalinity of the blood of a patient is brought back to normal coma may still persist

(3) Alkalies are liable to upset the stomach which is not desirable in diabetic coma

(4) Large doses of alkalies in a few bad cases have led to convulsions

Haldane demonstrated some time ago that if large doses of sodium bicarbonate were given to normal subjects receiving normal diet the tolerance for glucose was depressed and acetone bodies appeared in the urine

Hartmann and his co workers have shown that sodium lactate may be substituted for sodium bi-carbonate with gratifying clinical results The conversion of soda lactate to soda bicarb is gradual and hence there is less likelihood of the development of alkalosis Besides sodium lactate solution is non irritating stable and can be sterilized by boiling

In cases of amputations of the limbs *the use of ice refrigeration anæsthesia* appears to have gained considerable ground recently. The advantages of this method appear to be that it prevents shock, preserves tissue vitality and eliminates post operative œdæma.

Acute Infective Condition in Diabetes

It has already been stated that an infection aggravates the diabetic condition and frequently brings on acidosis and coma. It should further be remembered that unless the infective processes can be arrested the acidosis resulting from surgical infections goes on increasing and becomes very much resistant to treatment.

Recent *advances in the treatment of infective processes* in diabetes have, however, brought down the mortality rate considerably. Speedy healing of the tissues is insured by control of the hyperglycæmia with insulin, and the use of penicillin and the sulfonamide group of drugs has very considerably helped in bringing about quick arrest of the spread of the infective process.

Penicillin therapy.—It must be admitted at the outset that the recent introduction of penicillin has brought about a marked advance and a revolution in the treatment of certain infective processes in diabetes, particularly carbuncles and cellulitis. It has doubtless completely changed the outlook and the prognosis of these cases and if used early enough and in fairly big doses (500,000 units or more per day) the spread of the infection is arrested almost immediately and a subsidence of the process takes place without the necessity of any surgical interference. It has undoubtedly reduced the mortality rate and is doubtless a great boon to the diabetics.

Sulfonamide therapy.—Drugs of this group viz., sulfanilamide, sulfapyridine, sulfathiazole and sulfadiazine may also be used as successfully in diabe   as in nondiabetics

Sulfadiazine may however be considered to be the drug of choice in most infections

Furunculosis

Extensive furunculosis in diabetes is dangerous not only because the diabetic has usually a poor resistance to infections but also because it is liable to aggravate even a mild case of diabetes to a serious degree It is therefore very important to test the urine and the blood sugar early and frequently in all cases of boils and furuncles

The treatment of diabetic boils and furuncles has been dealt with later in connection with the diseases of the skin

Carbuncles

This is a fairly common complication and is not infrequently a fatal one for reasons already explained It should be remembered that the acidosis resulting from surgical infection is very much more resistant to treatment than a straightforward case of diabetic coma and the prognosis is often bad

Treatment

General —It is important to have the patient confined to bed from the very beginning All the general measures mentioned before should be scrupulously carried out

Penicillin therapy —This should be resorted to as early as possible in doses of 50 000 to 100 000 units every 3 or 4 hours depending on the seriousness of the infection and the response obtained A miraculous result has often been obtained if the therapy is started early

The use of sulfonamide group of drugs more particularly sulfadiazine is also advocated when necessary if the usual care is taken to watch for leucopenia anæmia and hæmaturia as in the case of non diabetics

Local treatment —One of the most efficient local applications is magnesium sulphate paste* according to the following formula —

R/

Dessicated magnesium sulphate	12 ounces
Acid carbolic (pure)	½ drachm
Glycerine (pure)	6 ounces

This should be applied over the rough surface on a piece of sterile lint and changed morning and evening

Surgical treatment —With early diagnosis and energetic treatment, surgery is seldom required in the treatment of carbuncle In neglected or spreading carbuncle with much slough formation, crucial incisions with under-cutting of the skin is a time honoured procedure The wound may require packing for 24 hours after which period the magnesium sulphate paste may be used with benefit

Auto hæmo therapy—In early cases this method of treatment has been found to be of use in limiting the extension of the carbuncle and in stimulation of the healing process

Vaccines —Auto-vaccines have been recommended for augmenting the immunological reactions

Circulatory Disorders and Gangrene

Diabetic Gangrene —If trauma and infections could be eliminated, death from diabetic gangrene would probably disappear The prophylaxis for gangrene includes care of the foot and treatment of minor foot injuries and a very careful control of diabetes A diabetic patient should pay more attention to his feet particularly his toe nails than his face Many patients infect themselves when trimming their own nails It is important to educate every diabetic on the care of his feet, specially with regard to the

* Heat magnesium sulphate to 100°C powder while hot and add glycerine and phenol gradually Strength of phenol is about 1 per cent

paring of corns and the dressing of blisters and the selection of the proper footwear *

Diabetic gangrene usually occurs in persons over 40 years of age and often starts from a trivial injury to the part. The condition is usually associated with gross arterial disease and is in the nature of an arterio-sclerotic gangrene. The prognosis is grave and death may ensue from toxemia or diabetic coma. Although insulin has robbed diabetes of many of its surgical complications, it cannot be expected [illegible] aid in limiting gangrene.

Treatment.—Immediate attention to and control of the acute infective processes and the acidosis caused thereby have just been described and it is essential that these should be followed with the utmost care and patience. Vigorous anti-diabetic treatment should be undertaken at once and a serious attempt made to check the spread of the infective processes *by suitable penicillin and sulfonamide therapy* as has just been described.

Conservative measures to save as much of the limb as possible may be successful in early cases. The object of surgical treatment is to convert a moist gangrene into a dry one and this may be effected by means of strict asepsis, adequate splintage and suspension of the limb. Foot baths and irrigation are now employed less frequently. Local amputation may be performed after a line of demarcation has formed.

In *serious cases* with gross arterial disease conservative treatment with a view to saving the limb is not justified. Where life is endangered the limb must be sacrificed and an early amputation is imperative. The classical site of selection is above the knee joint and a high amputation may be performed under gas and oxygen anaesthesia. Spinal anaesthesia is an alternative method preferred by some surgeons.

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* The shoes purchased should for example fit the feet a [illegible] of the eyes

Diseases of the Skin and Diabetes

Diabetic patients show a higher incidence of certain skin diseases than other persons It has been suggested that hyperglycæmia acts as a chemical irritant to the skin and is a factor of importance in the aetiology of certain diseases of the skin Even in non diabetic subjects suffering from diseases of the skin the blood sugar has often been found to be above normal In most of these cases there is also a simultaneous rise in the sugar content of the sweat* and of the skin †

The skin may be considered to be one of the main store houses of glycogen the other two being the liver and the skeletal muscles It is not sufficiently realized that the skin takes a very active part in converting the excess of sugar in the blood into glycogen and storing it as such In severe diabetes the glycogen content of the skin is very deficient and is replaced to a large extent by unutilized sugar and thus the cutaneous sugar value in diabetes is considerably increased

In diabetes the skin loses its power of converting the excess of sugar into glycogen the extent of which depends on the severity of the case The glycogen content of the skin is thus gradually depleted and is replaced by the unutilized sugar and thus the sugar content of the skin increases sometimes considerably The loss of power of glycogen formation the depletion of the glycogen content and the increase in the cutaneous sugar value take away much of the protective power of the skin and naturally makes it more vulnerable to infections The skin becomes dry and deteriorates in quality and texture It should always be kept in mind that the first step in the treatment of such condition should be the replacement of glycogen content of the skin by insulin

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* The average normal sugar content of sweat is 15 milligrammes per 100 c c

† The average normal sugar content of the skin is 65 milligrammes per 100 gm of skin

The following are some of the common varieties of skin affections met with in diabetes —

Allergy	Furunculosis
Carbuncle	Gangrene
Eczema	Impetigo
Erysipelas	Pruritus
Folliculitis	Xanthelasma

Of the above folliculitis furunculosis pruritus carbuncle and gangrene appear to be the commonest

Folliculitis and furunculosis—These are common complications of diabetes and are usually due to a deep staphylococcus infection

Treatment—The treatment should be commenced early If there is generalized folliculitis or furunculosis the whole body should be washed twice daily with a weak solution of potassium permanganate after which it should be wiped dry with a sterilized gauze without rubbing to avoid breaking open any pustule The individual furuncles should be touched with 4 per cent alcoholic solution of gentian violet or a solution of triple dye containing acriflavin brilliant green and gentian violet Then the following dusting powder should be dabbed all over the body —

Sulphur	½ drachm
Camphor	½
Zinc oxide	4
Boric acid	3
Talc powder	1 ounce

It should be remembered that the linen worn next to the skin should be changed daily

Vaccine or non specific protein therapy may be tried in resistant cases active anti-diabetic treatment should be undertaken

Pruritus—This is also one of the common complications and may be generalized or more commonly localized specially in or about the private parts The chief symptom

is an insatiable itching which is sometimes of such severity as to exclude the patient from society and to make him dull and morose The denudation of the epithelial surfaces caused by ceaseless scratching makes it easy for the micro organisms and parasites to gain entrance to the affected part and complicate matters. The highly acid sugary urine also coming in contact with the part makes it still worse This condition in male subjects is usually confined to the glans and the prepuce but may spread and produce a condition of balanoposthitis It may also spread over the scrotum and perineum and the inner part of the thighs The prepuce may be swollen and marked by radiating fissures

In females the whole vulva may be affected the eruption spreading on to the skin of the perineum and the inner part of the thighs The vaginal orifice may be swollen and excoriations and cracks may form In chronic cases hypertrophy and lichenification may take place

Treatment—The keynote of treatment is absolute cleanliness of the affected part use of simple lotions dusting powders or ointments as are found suitable and active anti diabetic treatment the last named of course being more important The use of a bland non irritating oil to prevent irritation during micturition is often helpful It should be remembered that one should not over treat this condition Simple cooling soothing liniments such as lint calamine (extra B P) sometimes give more relief than drastic methods of treatment

If the itching is severe the part should be washed with a hot lysol lotion (15 drops of pure lysol to 1 pint of hot water) and after drying 2 per cent brilliant green or 1 per cent mercurochrome solution should be applied Usually the condition clears up soon but if pruritus pudendi persists in spite of above treatment accompanied by severe anti-diabetic regime one should promptly search for a local cause which is usually prolapse leucorrhœa or urinary incontinence

Prophylaxis—It is the physician's duty to tell every one of his diabetic patients to keep their skin absolutely clean The patients should be warned about the complications which may follow if the hygiene of the skin is neglected The simple cuts the slightest blisters and the most trivial skin infections have been known to be followed by very serious consequences such as cellulitis and gangrene

Xanthoma Diabeticorum

This is a rare complication in diabetes A review of of the literature on the subject would show that during the last 100 years the number of cases described would not exceed one hundred and fifty During the last 25 years the author came across only two typical cases the more recent case being that of a young boy of 20 years of age * A description of the skin lesions in this case is given below —

Practically the whole body and the extremities were covered with small yellow-coloured papular lesions The extensor surfaces of the limbs suffered more than other parts The lesions present in the face were small discrete and confined mostly to the forehead The lesions in the hands were found to be generally confined to the sides and the back of the fingers and in the webs between the fingers and somewhat simulated scabies The palms of the hands and soles of the feet were sparsely affected The individual lesions were yellow or orange-coloured flat topped papules varying in size from a pin head to that of a split pea Most of these were solid but some were soft in consistency

Histopathology—The epidermis was mostly affected The main changes were confined to the corium In the sub papillary layer the capillaries were dilated in the affected area and there were cellular infiltrations round the dilated capillaries and also throughout the corium

* *Ind. Med. Ga* Vol 82 No 11 1947

These cells consisted of endothelial cells round cells and epitheloid cells There was all round fatty and fibrous degeneration in the corium the fatty degeneration being more marked than the fibrous changes Throughout the whole corium were deposits of fat globules and granules both inside the degenerated cells and the inter cellular spaces

The case described above presented a few unusual features the most noteworthy being that though the hyper glycaemia and the lipæmia particularly the latter were pronounced and though the skin lesions were wide spread the marked improvement in the clinical condition the quick disappearance of the hyperglycaemia and lipæmia and a resolution of the skin lesions were almost dramatic

Investigation—Among the noteworthy positive findings in the biochemical investigations* the hyperglycaemia was fairly marked the cholesterol content of the blood was extremely high As a matter of fact marked lipæmia was a special feature in the case The urine was loaded with sugar (8 to 10 per cent in 24 hours collection) and a fair degree of ketonuria was present

Treatment—The patient was put on a very low fat diet and an intensive anti diabetic treatment given Within a short period very satisfactory result was obtained and the skin condition improved considerably till it finally disappeared

The author is inclined to be of opinion that Xanthoma diabeticorum is related more closely to fat metabolism of diabetes mellitus than to the disturbance of carbohydrate metabolism

Bronzed Diabetes

Bronzed diabetes is a rare condition It is characterized by three conditions *viz* pigmentation of the skin and mucous membrane hepatic cirrhosis and diabetes

* For details consult original paper

Neuritis and Neuralgias

These are fairly common complications Diabetic neuralgia may affect all the nerves of the body but the common forms are the brachial sciatic and intercostal neuralgias The neuralgias in diabetes are usually more painful than the ordinary forms They may be symmetrical and do not yield to treatment readily The author had a few cases where the pain persisted (to some extent) even after the blood sugar had come down to normal by active anti-diabetic treatment

Neuralgia is often dependent upon the appearance of true neuritis A sharp distinction between simple neuralgia and true neuritis is often very difficult to make but the following points should be borne in mind in making a differential diagnosis

In neuritis—

(*a*) The pain is somewhat characterestic in that it is almost always worse at night and disturbs sleep Burning sensation with a feeling of tingling and coldness is also common While walking the patient gets a sensation as if he is walking *on* cotton wool pads Hyperæsthesia is also often present and is sometimes so marked that the patient is unable to bear the weight of even light bed clothes

One very noticeable symptom observed in some cases is that the patient gets much pain on light rubbing but feels relieved on deep pressure on the part

(*b*) There may be paresis or even paralysis

(*c*) There may be trophic disturbances such as perforating ulcer changes in the nail etc

(*d*) The tendon reflexes are diminished or absent

Treatment—It depends *on* individual cases

Attention should be directed to the elimination of all septic foci as far as practicable An active anti diabetic treatment should be followed by a judicious adjustment of

diet and insulin, avoiding undernutrition of the patient by a too rigid restriction of diet

In some intractable cases of severe neuritic pain beneficial results have sometimes been obtained by the use of cobra venom either alone or preferably in combination of with a neurotropic antigen such as "Denurin" in suitable dosages One however has to be very cautious in advocating this therapy

Vitamin B complex in suitable doses supplemented by thiamin chloride often does good and should be given a through trial

For the relief of the patient, hot fomentation (moist) may be ordered and anti neuralgic drugs prescribed Infra red rays may be applied

Pulmonary Tuberculosis and Diabetes

This is one of the most dangerous complications in diabetes and unfortunately, a fairly common one in the neglected cases The onset of tuberculosis in diabetes is usually insidious and the diagnosis of tuberculosis in its initial stage is particularly difficult to make and herein lies the danger

As soon as the physician suspects the onset of tuberculosis in diabetes he should use all the methods of diagnosis available to him, such as thorough and careful physical examination of the lungs, examination of the sputum blood count *x* rays etc to make the diagnosis as certain as possible, because it is quite obvious that if anything could be done for the patient to lessen his sufferings and to prolong his life, it is at this early stage

The author thinks that he should mention in this connection that at least in three cases of diabetes of a moderate grade of severity with tuberculosis that came under his observation, the diabetic symptoms disappeared suddenly and there was an unexpected improvement in the patient's

tolerance for carbohydrates without rigorous anti-diabetic treatment

Treatment—Though this is still unsatisfactory it is to be admitted that the outlook has definitely changed for the better since the advent of insulin. Early use of insulin and control of the diabetic condition are the keynote of treatment. Such treatment should be directed to both the diabetic and tubercular conditions simultaneously. Instead of dieting the patient by the usual rule of 30 calories per kilo of the body weight these patients should have at least 40 calories per kilo the excess of carbohydrates over the patient's tolerance being covered by a sufficient amount of insulin.

For instance a diabetic patient with tuberculosis weighing 60 kilos should usually have a diet yielding 2400 calories and consisting of 160 gms C 80 gms P and 160 gms F. In special cases still further increases may be made.

Diet should however be both nutritious and easily digestible. It should be specially rich in vitamins.

Special attention should be directed towards the general hygienic condition and surroundings of the patient. Rest in bed is essential. Early sanatorium treatment should be advocated in suitable cases.

It should also be mentioned that when artificial pneumothorax phrenic avulsion etc are necessary they should be done as in a normal person due regard being had to the control of the blood sugar prior to the operation.

Ocular Complications in Diabetes

Ocular complications have been found to be frequent in diabetic subjects and are often distressing problems. The following are some of the common complications in diabetes seen in the author's clinics arranged according to the frequency of their occurence —

1 Retinal hæmorrhages and retinitis
2 Waxy exudates in the retina

3 Errors of accommodation
4 Senile cataract
5 *Juvenile cataract*
6 Iritis
7 Optic atrophy
8 Retrobulbar neuritis

It thus appears that retinitis and retinal haemorrhages are the commonest and one of the most serious complications in diabetes particularly in the elderly chronic patient Deep retinal haemorrhages and waxy exudates often mark the primary stage of progressive diabetic retinopathy If proper precautions and care are not taken in the early stages the ocular damage in most of the cases becomes increasingly deteriorating sometimes leading to total blindness

The author s experience regarding the prognosis of pure diabetic retinitis (uncomplicated with such conditions as albuminuria arteriosclerosis and high blood pressure) is however fairly satisfactory provided that prompt and vigorous treatment is undertaken on proper lines A few cases are on record where further haemorrhages and exudates entirely stopped and further visual deterioration was prevented

In a certain number of cases however where vascular degeneration was progressive the retinitis and the haemorrhages became worse although the diabetes was adequately controlled These cases are fortunately few

Treatment —Nearly all the complications of the eye are amenable to treatment if not allowed to proceed too far An active anti diabetic treatment is essential and the patient must be made sugar free and the blood sugar brought down to normal The same rule applies to cataract which can be operated upon successfully and the recovery is likely to be uneventful if proper precautions are taken to control diabetes before the operation is performed In this connection the author would like to mention that bad cases of diabetes with marked hyperglycaemia and glycosuria

often complain of their eye sight becoming gradually worse during the first few days of treatment when the aim is the rapid de sugarization of the patient This peculiar condition is probably due to alteration in the fluid balance of the tissues, owing to rapid changes in the concentration of the sugar in the blood and the body fluids This naturally causes a difference in the osmotic tension and the lenses of the eyes being involved in this process cause these sudden refractive changes The patient who would naturally be alarmed if such things happened should therefore be told beforehand about the possibility of a temporary loss of vision being at the same time assured that there is absolutely no danger attached to this temporary phase and that everything will become normal in a short time

Some Controversial Questions

The question of marriage in diabetes

Now and again the physician is confronted with the following question from his patient— Doctor is it advisable for me to marry? In the previous chapters it has been mentioned that men suffering from diabetes are often found to be impotent and the women to cease to menstruate Both these however are usually functional in origin and are amenable to treatment if tackled early and persevered with long enough specially with the help of insulin Some authorities lay stress on the fact that while advising patients on such important matters the possibility of the hereditary nature of the disease should be pointed out to them but at the same time too much pessimism should not be allowed to grow in their minds The author's views regarding this have already been indicated in chapter III page 35 while dealing with the question of heredity in diabetes

In diabetic women the possibility of the disease getting worse during pregnancy should be explained to them

The question of pregnancy in diabetic women

It has already been stated that glycosuria in pregnancy is a frequent finding and is usually caused by the fact that in pregnant women there is an increased permeability of the kidneys to sugar and a lowering of the renal threshold this should not however be confused with diabetes proper because the blood sugar in these cases usually remains at the normal level In some pregnant women glycosuria which occurs is caused through the hyper activity of the anterior pituitary during pregnancy* and the blood sugar is sometimes raised and sugar tolerance diminished though temporarily

In dealing with the question of the presence of true diabetes in a pregnant woman a thorough investigation should be undertaken and a proper diagnosis made as early as possible If the pregnant woman is found to be a diabetic the nature of the severity of the case should also be determined and the patient treated accordingly

In treating the case of a pregnant diabetic woman the physician should remember the following important points —

(1) The pernicious vomiting in pregnancy in a diabetic woman may lead to severe acidosis and hence preventive and active treatment should be undertaken as soon as the early symptoms manifest themselves

(2) The diet of pregnant diabetic women should contain more carbohydrates than in the non pregnant ones as otherwise there is a chance of ketosis to develop

(3) In pregnant diabetic women there is an increased demand for carbohydrates during the latter part of pregnancy particularly in the last two months probably due to two main factors —(*a*) the foetus using up a large amount of glucose (about 30 to 50 grammes per day) which it removes from the maternal blood and (*b*) the additional

* Wall & Bose *Journal of Obstetrics of the British Empire* Vol 29 No 2 1922

insulinogenic function of the foetal pancreas These factors should be remembered with a view to making necessary adjustments regarding the carbohydrate intake and the dosage of insulin as otherwise severe hypoglycaemia is likely to develop suddenly

(4) Severe insulin hypoglycaemic shock in the mother may sometimes lead to the death of the foetus and bring about abortion This can certainly be avoided if proper precautions are taken

(5) The intra uterine mortality in diabetic woman is stated to be high

(6) The babies born of diabetic mothers are usually of large size and hence care must be taken to determine the size of the baby beforehand and if necessary an early induction of labour or Caesarean section should be envisaged

(7) The use of chloroform should be avoided during parturition

The introduction of blood sugar tests and the discovery of insulin have brought about a much brighter outlook regarding these cases and we can now safely allow the pregnancy to continue till term unless of course it becomes contra indicated by inability to control the disease by a judicious combination of diet and insulin It should however be kept in mind that in a diabetic pregnant woman there is often a tendency towards spontaneous abortion

CHAPTER XII

Diabetes in Children *

The diabetic child is of more than usual interest to those working on this disease, not only because it provides them with pure diabetic lesions unaccompanied and uncomplicated by any degenerative changes due to age, but also because it gives them a better opportunity of following up the effects of treatment. The prognosis in cases of diabetes in children was always thought to be a matter of considerable seriousness in the past, but it is not reasonable to take such a pessimistic view at the present day. There is no doubt that since the advent of insulin the outlook for these cases has been much brighter; a great deal may be done to improve the condition of the child which, if it does not prolong his life, will certainly make it more comfortable. This is possible because in a child the regenerative powers are at their highest and hence under proper care and suitable treatment there is much greater opportunity for the regeneration of the islet cells of the pancreas. The literature on the subject is replete with evidence that there is a much quicker regeneration of the islands of Langerhans in children than in adults. Boyd (1925) has reported an interesting case of diabetes in a boy who recovered but subsequently met with an accidental death. On autopsy the pancreas was found to be normal with the exception of scattered pyknotic nuclei in some of the island cells. Boyd had previously observed the presence of a very large number of island areas at the periphery of the pancreas, sometimes twelve or fourteen in a low power field. Bensly, in commenting on Boyd's paper, said that these small bulbous islands adjacent to a duct resembled those produced in ex

* Reprinted from *The Indian Medical Gazette*, Vol LXVIII, No 8, August 1933, page 443

perimental animals by the regeneration of newly produced islands



FIG 1

A Before treatment B Af er 3 eek f ea en



FIG 2

A Bef re rea ment B Af er 13 eeks of treatment

It may be stated with a certain amount of definiteness that taken properly in hand, the diabetic child should make considerable improvement within a comparatively

PROGRESS OF CASE (FIGURE 2) DIABETES CASE SHEET

Name P B H S Sex F Age 12 Religion Christian Physician Dr Bose

Continuous line — Blood sugar (Milligrammes per 100 c c)
Dotted line — Total Urinary sugar in grammes per day.

short time Such improvement in the general health and in the proper growth and development of the child takes

place quickly if the case is properly managed from the beginning The improvement is sometimes so marked that the child becomes scarcely recognizable within six weeks of the commencement of the treatment In p 147 are photographs of two of the author s cases which lend support to this statement (figures 1 2 and 3)

While therefore the final prognosis in cases of diabetes in children may not be predicated with any amount of certainty one should not take too gloomy a view of the disease in the present day of insulin treatment We know that it is possible now to turn a diabetic child from a living skeleton into a robust healthy being but whether or not this condition can be maintained permanently only further research can show

Age of onset — Diabetes in infants under one year of age is infrequent The youngest diabetic child amongst the author's series of cases was a boy aged 1 year and 4 months The author s experience has been that diabetes is less common in children under 5 years of age The youngest diabetic child in Joslin s series of cases was a baby 8 months old Ashby (1923) described the case of a four months old diabetic baby with gangrene of the toes Major and Curran (1925) reported a case with diabetic cataract in a baby 11 months old

Ætiology —This is still very obscure According to many observers heredity is an important factor Amongst most of the author s cases however heredity could not be traced as playing any important part in the ætiology of the disease It should be noted here that unlike diabetes in adults obesity does not seem to be of any importance as an ætiological factor in diabetes in children The author is inclined to the opinion that some inherent defect in the endocrine balance of the child leading to a disturbance in its normal mechanism is the causative factor though the exact nature of this disturbance is still obscure

Onset —In some of the author s cases the onset was sudden and the course was rapid One of the cases was

diagnosed for the first time while in a pre-comatose condition—the child having suddenly become ill with an eruptive fever three days previously. In other cases the onset was slow and insidious, diabetes being wholly unsuspected in the beginning. The usual history in most of these cases was that the child began to lose weight without any apparent cause and became peevish and sickly. The polyuria and unusual thirst which the child manifested was attributed to causes other than diabetes. One of these patients was treated for intestinal worms off and on for about 6 months, till he was brought to a miserable state of existence when luckily the urine was examined and found to be loaded with sugar, acetone and diacetic acid.

General considerations.—The characteristics of juvenile diabetes as distinct from the adult type are mainly its severity, rapid progression and liability to sudden complications.

Diabetic children are usually found to be taller than normal children of the same age and they are usually mentally alert, sometimes verging on precocity,* but at the same time, these children are undeveloped in other respects. This peculiarity has been noticed in most of the cases that came under the author's observation. They are usually sexually immature—the primary and the secondary sexual characteristics being either unusually delayed or absent altogether. In one of the author's cases, a somewhat remarkable one of a girl aged 17 (*see figure I*) there were no signs of catamenia, the uterus was of the infantile type, and the secondary sexual characters were

* The following note as to the special peculiarities of the diabetic children was prepared for the author by an observant staff nurse in charge of the children's ward.

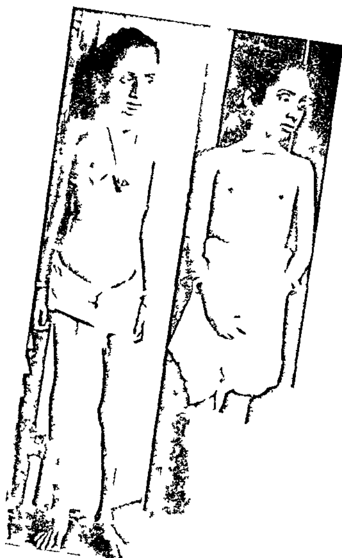
(1) Children suffering from diabetes are more intelligent than other children of the same age.

(2) *They are very precocious and quick* at understanding.

(3) They are inclined to be very cunning and sly in their ways.

(4) Their nature is very sensitive, and great kindness and tact is required in dealing with them.

(5) At times they are depressed, irritable and hysterical, and need a little firm handling which usually brings them round quickly.



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B f

absent The girl behaved like a child of 11 or 12 only though mentally she was very alert and more than usually intelligent and followed the line of treatment with greater understanding than those many years her senior

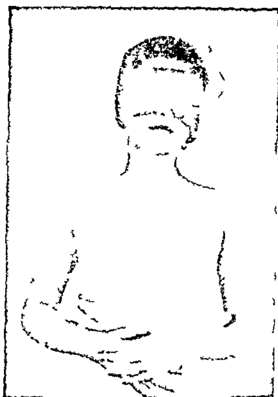


FIG 4
Girl aged 17 years (The lack of development is apparent)

This peculiar conjunction namely superiority in height precociousness and sexual immaturity appears to the author to point to a condition which has been brought about by the absence of a proper involution of the thymus gland leading to a condition of hyperthymism

We know that the thymus is directly antagonistic to the gonads in physiological manifestations and in the condition of hyperthymism there is almost always an associated condition of partial or total insufficiency of the gonads. We know that one of the peculiarities of hypogonadism is that if this condition takes place before puberty the skeletal development is somewhat excessive in the direction of length, thus explaining the somewhat excessive length of



Fig 5
A group of Diabetic Children

lower limbs. This gives a partial explanation why the sexually immature diabetic child is usually taller than other children of the same age.

Treatment—Though the principle underlying the treatment of diabetic children is more or less the same as

that of an adult yet there is a considerable difference in many essential details For instance it should always be borne in mind that the food requirements of growing children are proportionately much greater than those of the adult and a diet which is insufficient in its total caloric value or inadequate as regards the protein ration may cause serious harm The growing child requires a generous diet which should not only yield the total caloric value needed *according to the age of the child but should contain the* proper amount of protein to maintain health and vigour and to promote growth It should also be borne in mind that children as a rule cannot take the same proportion of fat per kilogramme of body weight as an adult and they are more liable *to develop acidosis*

The essential difference between the dietetic treatment of diabetic children and adults lies in the fact that whereas in the case of adults the protein requirement under basal conditions is approximately about one gramme per kilogramme of body weight in the case of diabetic children the protein requirement varies inversely according to the age—*i e*, the younger the child the greater is the protein *requirement per kilogramme The same rule holds good* in the case of the carbohydrate as well as in the total caloric requirements The fat requirement by diabetic children is also essentially different from that of an adult The ratio of fat to carbohydrate in the diet of the former should be much less than in that of the latter because diabetic children are more liable to develop ketosis on a diet disproportionately rich in fat at the same time it should be remembered that the fat content *in the diet should not* be too low because fat serves as an important carrier of the fat soluble vitamin A which is essential to growth The following table gives the approximate carbohydrate fat protein and the caloric requirements of diabetic children *in the different periods of their lives* It should however be borne in mind that the proportions given below are only average and have to be varied at times according to the

nature of the case and according to complications present or arising

Age of the child	*Requirements per kilogramme of body weight*			
	Fat	Carbohydrate	Protein	Calories
1–2 year	3 gms	12 gm	4 gm	90
3–5	3	9	4	80
6–10	3	6	3	60
10–15	3	3	2	50

It will be seen from the above table that the caloric requirement per kilogramme of body weight as well as the protein and the carbohydrate requirements increase inversely according to the age—*i.e.* the younger the child the greater is the food and the calorie requirement per kilogramme of the body weight. The fat requirement however has been kept at an arbitrary figure *viz.* 3 grammes per kilogramme but the ratio between the fat and carbohydrate in the diet has been altered by propor-tionately increasing the carbohydrate quota of the diet. For instance it will be seen that the proportion of fat to carbo-hydrate in the first two years of life has been kept as low as 1 to 4. As the age increases the proportion of fat has also been increased in relation to the carbohydrates so that at the end of the table a child between the ages of 10 to 15 years gets a proportion of 1 to 1 which approaches the normal adult proportion.

It should also be remembered by the doctor prescribing diets for diabetic children that he must take into consideration the suitability of the food stuffs according to the age of the child. For instance the diets of infants under 2 years should mainly consist of milk. For bigger children eggs, fish, potatoes, bread, butter, vegetables, fruits etc. should be prescribed.

Insulin therapy.—The principle of the treatment is the same in children as in adults If the case is an uncomplicated one and of mild nature and if the blood sugar is not excessively high, the effect of dieting alone should be tried for a few days, in order to see whether this alone has *an effect in reducing the blood and urinary sugar*, and in improving the general health of the child If dietetic treatment, continued for about a week, fails to make any impression or if the child loses weight, insulin should be commenced Of course, if the case is of a severe nature, or if there are complications insulin treatment should be started at once

Regarding the dosage of insulin, no hard and fast rule can be laid down but in as much as the dose may vary in individual cases it should be mentioned here that in children, the *proportionate* dose of insulin per kilogramme of body weight is usually higher than in adults because of the high carbohydrate content of their diet It should also *be remembered that some of the diabetic children* require relatively big doses to make their urine sugar free One of the author's cases a child aged 5 years and weighing only 33½ pounds (or approximately 15 kilogrammes) required as much as 30 units of insulin daily (given in two doses) to make his urine sugar free

As a general routine, however, it can be laid down that in *mild cases uncontrolled by diet alone*, it *is best to* commence with small doses of, say, 2 to 3 units once or twice daily In more severe cases, with high blood sugar, *commence with 5 to 6 units twice daily* As in the case of adults the dose should be increased gradually until the glycosuria disappears and the blood sugar becomes normal

It must be remembered that in treating cases of diabetes in children, not only must the urine be kept sugar free and the blood sugar kept within normal limits but very careful attention must be given to the proper growth *and development of the child The child must grow in* height and gain in weight like other normal children In

cases where the urine is made sugar free but the child does not grow or gain in weight the diet must be raised and extra doses of insulin given to keep the urine sugar free on the other hand if the gain in weight is abnormally rapid the diet should be cut down and the dose of insulin adjusted accordingly

Prognosis—It is undoubted that insulin has made a great difference in the prognosis It has not only helped to make their lives comfortable but it has prolonged the lives of these children and made it possible for them to grow and develop almost normally Joslin's statement with regard to this point is very apposite he says Thirty years ago when I began treating diabetic children I counted the days they lived *It is hard to believe but it is true* that I am now beginning to measure their lives in decades

CHAPTER XIII

Glycosuria and Life Insurance

It frequently happens that a person otherwise hale and hearty is refused insurance on his life by some of the reputable insurance companies because the medical report indicates the presence of a reducing substance in the urine The matter is no doubt very important from the point of view of the company which has every right to safe guard its own interests but it is also of vital importance to the prospective insured person whose only chance of making some provision for his family in the event of his sudden death happens to be an insurance on his own life

There are two essential points to which the attention of the medical officers of insurance companies should be drawn and on which they must satisfy themselves before they can do full justice to the company and its client either by accepting or refusing the life of the proposer

He will have to find out —

(1) Whether the reduction of the copper salts is due to sugar or some other reducing substance which may be present in the urine It should be borne in mind that the substances which reduce the copper solution may be many * the common amongst them being some of the drugs includ ing rhubarb senna amido pyrine ascorbic acid etc high concentrations of the normal urinary constituents including creatinine uric acid etc glycuronates or some of the abnormal metabolic urinary constituents such as homo gentisic acid

(2) In case that substance is sugar the next le is s glucose or

detect ou

any other form of sugar such as laevulose lactose galactose pentose etc

If however it is found that glucose is present in the urine the next point to decide is whether the patient is a true diabetic or the glycosuria is non diabetic in origin mention about which has already been made in the text previously

In usual practice however most insurance companies *depend on the urinary sugar as the criterion for the* diagnosis of diabetes and usually reject cases which show glycosuria on routine examination

This procedure could have been excused in the old days when the diagnosis of diabetes mellitus mainly depended on the presence of sugar in the urine and thus the proposals of many innocent non diabetic individuals *were either declined or accepted under special circum* stances as to short term and high rates

But this crude method of diagnosing diabetes by the mere presence of sugar in urine has no excuse in these days when we have so many modern means at our disposal for the purpose of finding out not only whether the person under investigation is a true case of diabetes mellitus but also in case it proves to be diabetes at what stage it is Every medical officer of an insurance company should make it his business to investigate the doubtful cases because if that is not done it may mean considerable injustice to particular individuals and an innocent non diabetic person may be classed as a diabetic The medical officer who through over caution (in the interest of the company) or indifference rejects a proposer on the basis of the copper test alone prejudices him in the eyes of other insurance companies whom he may approach subsequently and thus he is either rejected again or unjustly overloaded On the other hand if by proper and thorough investigations it is *found that* there are signs of the beginning of diabetes in a young proposer the medical officer has every right and

it is his duty to reject the person in question, because the company has to view the proposer not as he is at present but as he is going to be It has absolutely no power to control the conditions under which the proposer may live nor assume that by suitable anti-diabetic treatment, he may ward off the disease

In cases of diabetic glycosuria in the aged the outlook is somewhat different Here, if proper discretion is used by the medical officer, he may, after a thorough investigation into the history and the progress of the disease, recommend the proposal for acceptance, subject to special conditions as to premium, etc, or reject it altogether

There is another important matter which an insurance doctor would do well to remember, namely, that it is often a matter of chance whether sugar is detected in the urine or not If the proposer is a mild case of diabetes and appears for examination in a fasting condition no sugar will *probably be found in the urine If he comes 2 to 3 hours* after a full meal he will probably pass a fair amount of sugar in the urine It is mainly for this reason that the patient gets puzzled by being told by one doctor that there is sugar in his urine, while another equally competent medical man tells him that there is none The relation of glycosuria and hyperglycæmia to the meals taken has been described in Chapter VII

To safeguard the interest of the company and *to be* equally just to the proposer, the medical officer in doubtful cases should—

(1) make the person drink 50 to 100 grammes of glucose dissolved in about 4 oz of water in his presence, and after about 2 hours collect a specimen of his urine and examine for sugar,

(2) test the fasting level of blood sugar of the patient or, better still, do a glucose tolerance test

Attempts at fraud practised by proposers on insurance companies—Attempts are now and then made by diabetic individuals to pass the tests of the insurance doctor by fasting themselves for periods varying from 18 hours onwards to make themselves sugar free at the time of the examination If there is suspicion to this effect the examiner should test the urine for acetone bodies which if present would confirm the suspicion A test meal of glucose should be given to the patient in these circumstances and the urine examined about 2 hours after If possible a glucose tolerance test should be done

In these modern days of insulin a diabetic individual may seek the help of a doctor and fortify himself by suitable adjustment of diet and insulin before appearing for examination by the insurance doctor Here too the glucose tolerance test will clear the diagnosis in cases of doubt

If every candidate for life insurance appearing for medical examination be made to take about 3 ounces of glucose dissolved in water and the urine collected and tested for sugar about 2 hours after much trouble worry and unpleasantness would in the opinion of the author be saved A solution of glucose of suitable strength may be kept in stock As soon as the patient appears before the doctor he may be asked to empty his bladder and immediately afterwards receive the drink of glucose The medical man meanwhile may go on with the other examinations At the end of 2 hours he collects another specimen of urine and tests both samples If this is carried on as part of the routine work the patient never suspects anything but thinks that the drink that is offered to him is part and parcel of the usual test On the other hand the doctor receives much valuable information which would not otherwise be available to him In cases where even this procedure leaves room for doubt the patient may be made to undergo a more crucial test

CHAPTER XIV

A Simplified Method for Estimation of Sugar in Blood *

That normal blood contains sugar was known even before the time of Claude Bernard and since then numerous methods have been devised by workers all over the world to estimate the sugar many of these being obsolete by now Formerly, the estimation of sugar in the blood used to be a tedious process but now a days it is comparatively simple Even then however nearly all the methods for blood sugar estimation require a well fitted laboratory and a fairly well trained worker to carry out the test

The importance of blood sugar as a factor for consideration has increased enormously since the insulin treatment has come into use All cases of diabetes undergoing insulin treatment require periodical sometimes daily examination of blood sugar In large cities like Calcutta with well equipped hospitals and laboratories and trained workers in them, this is always possible, but the same cannot be said of the distant mofussil towns and villages in some of which even a qualified medical man is wanting

A doctor in such a place is very much handicapped in treating a case of diabetes with insulin not being able to get any idea of what the initial blood sugar level is and also what changes take place in the blood sugar during insulin treatment It has been suggested that where blood sugar estimation is not possible, insulin treatment can be carried out by relying on the urinary sugar only This appears to us to be an unscientific and sometimes a dangerous procedure Reference has already been made to a few cases of renal glycosuria treated with insulin with results

* Demonstrated by the author at the Scientific Exhibition of the Seventh Congress of the Far Eastern Association of Tropical Medicine December 1927

just short of disaster Even in a case of diabetes one does not get a clear indication about the proper dose of insulin to be injected and also about the interval of time between injections without a knowledge of the patient s blood sugar *and this is essential for successful treatment of diabetes* mellitus To give too small a dose of insulin and at too long intervals will not do much good to the patient to give an overdose of insulin on the other hand may mean trouble

In order to help medical practitioners in mofussil towns and villages to carry out insulin treatment successfully by regular blood sugar tests the author has devised* a simplified method for the estimation of the sugar content of blood which would be fairly accurate for clinical purposes and at the same time sufficiently easy and quick for the average busy practitioner to carry out Controls by authenticated blood sugar methods show that the results obtained are quite accurate for clinical purposes

General principle of the method

(1) Precipitation of the protein and the colouring matter of the blood by means of precipitating reagents and then filtering it

(2) Boiling the crystal-clear blood filtrate (containing glucose) with alkaline copper solution so as to get the copper reduced by the sugar in the blood

(3) Getting a blue coloured compound† by the interaction of phospho-molybdic acid and the reduced copper

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* The complete apparatus is manufactured by the Bengal Chemical & Pharmaceutical Works Ltd Calcutta

† When [illegible] solu [illegible] (n [illegible] on is [illegible] blue [illegible] the intensity of the blue colour developed being directly proportional to the amount of reduced copper present which again is dependent on the amount of sugar present

(4) Comparison of the blue colour thus produced with the colour produced by a standard glucose solution of known strength, similarly treated This is done by means of a comparator devised for the purpose Dilution has to be made of the deeper coloured solution until both the solutions match exactly in colour, the amount of dilution made is then noted and the result read off from the table

Apparatus required

(1) Test tube rack
(2) Ordinary glass tube for making oxalated tubes *
(3) Test tubes (size 4 inches by ½ inch) for collecting oxalated blood
(4) Pipette (3 c c) with three divisions for measuring distilled water
(5) Extraction tubes (2 inches by ¾ inch) for extracting blood in distilled water and for filtering the same after precipitation
(6) Pipette (0 2 c c) with one mark for measuring blood for estimation of sugar
(7) Pipettes (0 4 c c) with one mark for measuring the two precipitating reagents
(8) Small glass rods for stirring up the blood after precipitation
(9) Small funnels filter papers (starch free—5 5 cm) for filtration *of blood after precipitation*
(10) Measuring flask (50 c c) for making up "stock" and 'standard' glucose solutions
(11) Pipettes (1 c c) with one mark for preparing and measuring *"standard" glucose solution*
(12) Graduated tubes (30 c c) for boiling the 'standard" glucose and the 'blood filtrate" with copper solution
(13) Pipettes (2 c c) with one mark for measuring out blood filtrate, *alkaline copper solution and phospho-molybdic acid solution*
(14) Tripod stand, copper water bath and spirit lamp for boiling purposes
(15) Comparator (Fig 5)

* The easiest way of preparing an oxalated tube is to blow into the test tube with a glass tube and then to sprinkle some finely powdered *neutral potassium oxalate inside The inner walls of the tube* thus becoming moist through
uniform layer Care sh
potassium oxalate po
coagulant being roughly
In cases where the
sodium fluoride should

Reagents required

(1) Powdered potassium oxalate (neutral), for preparing oxalated tubes

(2) Sodium tungstate (pure crystals) 10 per cent solution

(3) Acid sulphuric—2/3rd normal solution

(4) Alkaline copper solution, which is prepared as follows — Dissolve 40 grammes of pure anhydrous sodium carbonate in about 400 c c of distilled water with the aid of heat if necessary Dissolve 4 5 grammes of "extra pure" copper sulphate crystals in about 100 c c of distilled water Mix the two solutions thoroughly in a litre flask Dissolve 7 5 grammes of pure tartaric acid separately and add the solution to the flask The receptacle in which the copper sulphate is dissolved must be repeatedly washed in distilled water and the washings added to the flask When cool distilled water should be added and the solution made up to the mark Filter

(5) Phospho-molybdic acid solution, prepared as follows — Dissolve 35 grammes pure molybdic acid (free from ammonia) in 200 c c of 10 per cent sodium hydroxide solution Add another 200 c c of distilled water and boil until all traces of ammonia are driven off (This can be tested by presenting a glass rod dipped in strong hydrochloric acid) Cool and add 125 c c of phosphoric acid (85 per cent) When sufficiently cool make up to 500 c c with distilled water

(*N B*—This solution should be of such a strength that 2 c c of this will completely discharge the blue colour from 2 c c of the alkaline copper solution It is advisable to test these reagents occasionally and to make blank experiments with them from time to time)

(6) "Stock" glucose solution—1 per cent , prepared as follows — Take two *Grape Sugar Tablets* (*Merck*), *each containing* 0 25 *gramme of glucose* directly into the 50 c c measuring flask Fill half the flask with *a saturated solution of benzoic acid* Shake the flask till the tablets dissolve completely and then fill the flask up to the mark with saturated benzoic acid solution The solution should be bottled and kept well stoppered This solution will keep proper strength for about a month

(*N B* —To prepare "standard" glucose solution from the stock, wash out the 50 c c flask with distilled water thoroughly Measure out 1 c c of the "stock" glucose solution by means of the 1 c c pipette and deliver it into the flask Make up to the mark with distilled water and shake well This solution should be made fresh each time 1 c c *of this solution will contain* 0 2 *milligramme of glucose*)

Method of estimation

With the usual aseptic precautions draw ½ to 1 c c of blood from the vein With a little practice this small amount of blood can also be collected from a deep prick of finger or the ear lobe (capillary blood) To obtain this the patient should be instructed to dip the hand in warm water and after thorough drying to swing the arm vigorously backwards and forwards for a little while Rub the finger tip thoroughly with cotton wool soaked in ether and make a fairly deep puncture with a sterilized sharp surgical needle (An ordinary sharp intravenous needle serves the purpose as well) If the puncture is done quickly enough very little pain is felt A good flow of blood can be obtained by squeezing the finger in a proper and systematic way The blood may be collected either directly in the 0 2 c c pipette (by capillary action) or into the oxalated tube from which the blood can be measured out

In an extraction tube measure out 3 c c of distilled water by means of the 3 c c pipette Accurately measure out 0 2 c c of blood by means of 0 2 c c pipette and deliver it into the extraction tube Shake lightly and wait till all corpuscles become laked and the solution becomes clear red (Plate I A)

Now add 0 4 c c of 10 per cent sodium tungstate solution followed immediately by 0 4 c c of 2/3 N sulphuric acid by means of the two 0 4 c c pipettes and stir with a glass rod The addition of sodium tungstate and sulphuric acid precipitates the protein and the colouring matter of the blood The precipitate is reddish at first but soon becomes viscous and turns greyish brown (Plate I B)

When the precipitation is complete the solution is filtered through the starch free filter paper The filtrate obtained should be crystal clear For the estimation measure out 2 c c of the clear filtrate into the special graduated 30 c c tube marked blood filtrate by means of 2 c c pipette Into the other 30 c c graduated tube marked

standard glucose', take 1 c c of the standard glucose solu tion by means of another 1 c c pipette with one mark and add 1 c c of distilled water to it Now add 2 c c of alkaline copper solution to each of these two tubes by means of a 2 c c pipette Shake the two tubes by gently stroking the bottom of the tubes against the palm of the hand

The two tubes are now introduced into the copper water bath *in which water is already boiling* and allowed to remain there for 10 minutes They are then removed from the bath and the contents will be found to be of bluish colour with a reddish brown precipitate of cuprous oxide at the bottom of the tube Two c c of phospho-molybdic acid solution is then immediately added to each of the two tubes

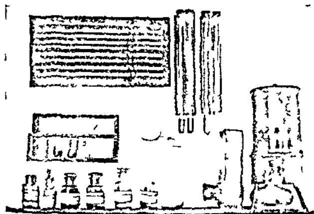


FIG 5
Blood-sugar apparatus dev sed by the author

by means of a 2 c c pipette A brisk effervescence occurs and the solutions in the two tubes turn deep blue Phospho-molybdic acid as has already been stated discharges the blue colour of unreduced copper but will deepen the colour by combining with the reduced copper oxide The intensity of the blue colour developed is directly proportional to the amount of the reduced copper

present which again is dependent on the amount of the sugar present Shake the two tubes by slightly inclining the tubes and tapping the bottom against the palm of the hand The solution in each of the two tubes should stand at the 6 c c level

Now put these two tubes inside the Comparator (Fig 5) and add distilled water very carefully to the tube having a deeper colour (either the standard or the blood filtrate in whichever tube the colour of the solution is deeper) Dilution with distilled water is carried on until the two solutions are matched in colour exactly After addition of distilled water each time mix the contents thoroughly by putting in the cork and inverting the tube

Calculations

It has already been mentioned that the intensity of the blue colour after addition of phospho molybdic acid depends on the amount of the reduced copper present which in its turn is in proportion to the amount of sugar present in the contents of the two tubes

Now when the solutions in the two tubes are exactly matched in colour it may be assumed that the *concentration* of sugar in both of them is the same but the *quantity* of sugar present in each will vary in direct proportion to the respective volumes of the solutions In the present case the solution in the tube marked S is known to contain 0 2 mgm of sugar and from this the concentration of sugar *in the other is easily found out by calculation*

Let us take a concrete example Let us suppose that the solution in the standard tube is deeper in colour and had to be diluted up to 12 c c to match exactly in colour *with the 6 c c of the solution in the* blood filtrate tube Here although the concentration of sugar in two solutions is the same the quantity of sugar present in the standard tube is double of what is present in the unknown tube *the quantity being directly proportional* to the volumes of the solutions contained in the two tubes

We know that the 12 c c of the solution in the standard tube contains 0.2 mgm of glucose Therefore the sugar content of the 6 c c of the solution in the unknown is half *i e*, 0.1 mgm

The proportional contents of the sugar in the unknown solution is thus readily calculated by simple rule of three —

Standard	Unknown	Strength of glucose	
12 c c	6 c c	0.2 mgm	x

$$x = \frac{6 \times 0.2 \text{ mgm}}{12} = 0.100 \text{ mgm}$$

It will be remembered that originally 0.2 c c of blood was taken for experiment and was made up to a total volume of 4 c c , after filtration only 2 c c were taken for estimation Therefore the quantity of blood actually taken for experiment was 0.1 c c

Now if 0.1 c c of blood contains 0.1 mgm of sugar 100 c c of blood will contain 100 mgm which is equivalent to 0.1 gm (per cent)

Suppose however that the solution in the blood filtrate tube is deeper in colour and has to be diluted to 8 c c to match in colour with the solution in the standard tube As the quantity of sugar in the two solutions will be proportional to their respective volumes and as the 6 c c of the standard solution contains 0.2 mgm of glucose the amount contained in the 8 c c of the unknown solution can be found out as follows—

Standard	Unknown	Strength of glucose	
6 c c	8 c c	0.2 mgm	x

$$x = \frac{8 \times 0.2 \text{ mgm}}{6} \quad 0.266 \text{ mgm}$$

Now 0.1 c c of blood contains 0.266 mgm of glucose Therefore 100 c c of blood will contain 266 mgm which is equivalent to 0.266 gm (per cent)

For easy calculation the author has worked out a table which will give the results at a glance Simply note the

readings of the standard and that of the unknown in c cs and find out from the table the percentage of blood sugar at once without going into calculations

For the sake of convenience the estimation of blood sugar may be summarized, as follows step by step —

(1) Take 3 0 c c of distilled water in an extraction tube

(2) Measure out 0 2 c c of the oxalated blood and add it to the distilled water Mix thoroughly

(3) Add 0 4 c c of 10 per cent sodium tungstate, immediately followed by 0 4 c c of 2/3N sulphuric acid in the extraction tube containing blood Stir with a glass rod

(4) Filter into another extraction tube *(During the time when the filtration is going on, the "standard' glucose solution may be prepared)*

(5) Into the special 30 c c graduated tube (marked "standard glucose') take 1 c c of the standard glucose solution (containing 0 2 mgm of glucose) and add 1 c c of distilled water to it Into another similar tube, (marked 'blood filtrate) take 2 c c of the blood filtrate

(6) Add 2 c c of the alkaline copper solution to each of these tubes Shake

(7) Put both these tubes in the *boiling* water bath* for 10 minutes

(8) Take the two tubes out of the water bath and add 2 c c of Phospho molybdic acid to each The solutions in the two tubes turn blue Shake by gently stroking the bottom of the tubes against the palm of the hand

(9) Put the two tubes inside the 'Comparator', and add distilled water very carefully to the deeper coloured solution till the colours in the two tubes exactly match each other

(10) Take the readings in the two tubes in c c, and calculate or read the results directly from the table

* To save time it is advisable to set the water bath boiling just before starting the experiment

TABLE I

Solution in "Standard" tube diluted

Reading in "standard" tube in c cs	Reading in "blood filtrate" tube in c cs	Result (Percentage)
6.0	6.0	0.200
6.1		0.196
6.2		0.193
6.3		0.191
6.4		0.187
6.5		0.184
6.6		0.182
6.7		0.179
6.8		0.176
6.9		0.174
7.0		0.171
7.1		0.169
7.2		0.167
7.3		0.164
7.4		0.162
7.5		0.160
7.6		0.158
7.7		0.156
7.8		0.154
7.9		0.152
8.0		0.150
8.1		0.148
8.2		0.146
8.3		0.141
8.4		0.143
8.5	ditto	0.141
8.6		0.139
8.7		0.138
8.8		0.136
8.9		0.135
9.0		0.133
9.1		0.132
9.2		0.130
9.3		0.129
9.4		0.127
9.5		0.126
9.6		0.125
9.7		0.123
9.8		0.122
9.9		0.121
10.0		0.120
10.1		0.119
10.2		0.118
10.3		0.116
10.4		0.115
10.5		0.114
10.6		0.113
10.7		0.112
10.8		0.111
10.9		0.110
11.0		0.109

Reading in "standard" tube in c cs	Reading in "blood filtrate" tube in c cs	Result (Percentage)
11.1	6.0	0.108
11.2		0.107
11.3		0.106
11.4		0.105
11.5		0.104
11.6		0.103
11.7		0.102
11.8		0.101
12.0		0.100
12.1		0.099
12.2		0.098
12.3		0.097
12.4		0.097
12.5		0.096
12.6		0.095
12.7		0.094
12.9		0.093
13.0		0.092
13.2		0.091
13.3		0.090
13.4		0.089
13.6		0.088
13.8		0.087
13.9		0.086
14.1		0.085
14.2	ditto	0.084
14.4		0.083
14.6		0.082
14.8		0.081
15.0		0.080
15.2		0.079
15.4		0.078
15.6		0.077
15.8		0.076
16.0		0.075
16.2		0.074
16.4		0.073
16.6		0.072
16.9		0.071
17.1		0.070
17.4		0.069
17.7		0.068
18.0		0.067
18.2		0.066
18.5		0.065
18.8		0.064
19.1		0.063
19.4		0.062
19.7		0.061
20.0		0.060

TABLE II

Solution in "Blood filtrate" tube diluted

Reading in standard tube in c cs	Reading in blood filtrate tube in c cs	Result (Percentage)	Reading in standard tube in c cs	Reading in blood filtrate tube in c cs	Result (Percentage)
6.0	6.0	0.200	6.0	9.1	0.303
	6.1	0.203		9.2	0.306
	6.2	0.206		9.3	0.310
	6.3	0.210		9.4	0.313
	6.4	0.213		9.5	0.316
	6.5	0.216		9.6	0.3[illegible]0
	6.6	0.220		9.7	0.323
	6.7	0.223		9.8	0.326
	6.8	0.226		9.9	0.330
	6.9	0.230		10.0	0.333
	7.0	0.233		10.1	0.336
	7.1	0.236		10.2	0.340
	7.2	0.240		10.3	0.343
	7.3	0.243		10.4	0.346
	7.4	0.246		10.5	0.3[illegible]0
ditto	7.5	0.250	ditto	10.6	0.353
	7.6	0.253		10.7	0.356
	7.7	0.256		10.8	0.360
	7.8	0.260		10.9	0.363
	7.9	0.263		11.0	0.366
	8.0	0.266		11.1	0.3[illegible]0
	8.1	0.270		11.2	0.373
	8.2	0.273		11.3	0.3[illegible]6
	8.3	0.276		11.4	0.380
	8.4	0.280		11.5	0.383
	8.5	0.283		11.6	0.386
	8.6	0.286		11.7	0.390
	8.7	0.290		11.8	0.393
	8.8	0.293		11.9	0.396
	8.9	0.296		12.0	0.400
	9.0	0.300			

Method of collection of blood for sugar estimation

To get the fasting level of blood sugar the blood should preferably be drawn in the morning before the patient has any food *i e*, about 12 hours after the previous night's meal The blood should be prevented from clotting by the use of suitable anti-coagulants and if the specimen is being sent out by post to a distant laboratory a suitable preservative should be added to prevent glycolysis

With the usual aseptic precautions draw 1 to 2 c c of blood from the vein and collect the blood directly into an oxalated tube Mix well and if the examination is not likely to be done within a few hours add 1 drop of 10 per cent formalin as a preservative

Another method of preserving blood samples is to mix 3 parts of powdered potassium oxalate with 1 part of potassium fluoride Take 0 01 gm of this mixture in a clean test tube and collect 1 c c of blood directly into it Mix thoroughly and send out to the laboratory for examination

CHAPTER XV

Examination of the Urine

Almost invariably, the first diagnosis of glycosuria or diabetes is made from the examination of the urine Diabetes is a very insidious disease and, when sugar appears in the urine, it may be taken for granted that the disease has made some progress in the system It has to be borne in mind that the detailed tests for the proper diagnosis of diabetes in the prediabetic stage are not always possible owing to a variety of causes but a systematic examination of the urine can always be made by every doctor at the bed side or in the laboratory If it is done carefully and syste matically many cases of true diabetes would be detected at a comparatively early stage when the disease is more amenable to treatment

Everyone will admit that when diabetes has advanced so far as to present the usual symptoms and when the patient passes sugar albumin or acetone in the urine the disease is in a fairly advanced stage and the chances of recovery are remote If every practitioner—medical surgical or gynæ cological—would make it a rule to have the urine of their patients examined for sugar, al nd acetone at the earliest opportunity, many c would be averted and many patients would b ds f foreseen what ne serious

It is in have *morning* ine this lead to that is sugar in n men (whic dinner) is get either a m) or a

It should be remembered however that examination of single specimens of urine and the determination of the "percentage" of sugar present therein is often fallacious be cause it will naturally vary according to the previous diet of the patient and the dose of insulin if administered It certainly does not give any idea as to the total sugar loss of the patient in 24 hours The most important thing is to find out how many grammes of sugar the patient is excreting in 24 hours The method followed by the author has been described in Chapters IX and X

For the purpose of following up a case the method of calculating the total sugar excretion in grammes in 24 hours will be found very helpful in the proper adjustment of the diet and the dosages of insulin in individual cases

Sugar in normal urine

It has been proved beyond doubt that normal urine contains some amount of glucose The amount present is so small that it is not sufficient to give a positive result with Fehling's or Benedict's test Folin Myers, Benedict Oster berg and a few others worked on this subject and they succeeded in finding various methods for detection and estimation of sugar in normal urine The author also worked on this line in collaboration with the late Dr Mackenzie Wallis at St Bartholomew's Hospital in London and they were able to find a new and reliable colorimetric method for the estimation of sugar in normal urine* As a result of analysis of about 200 samples of normal urine in Europeans by this new method they found that the concentration of sugar in urine varied between 0 06 and 0 09 per cent amounting to a total of 0 8 to 1 gramme in twenty four hours In normal healthy Indians the range of variation according to the author's findings is from 0 06 to 0 10 per cent

* Glycosuria in pregnancy Journal of Obstetrics and Gynaecology of the British Empire, Vol XXIX, No 2 Summer 1922 (Wallis and Bose)

Benedict's qualitative test for sugar

This is a comparatively simple test for sugar in urine and it has at present displaced nearly all other reduction tests for sugar It is a single solution and keeps for a fairly long time

One of its chief advantages over other methods is that it tells us at once the approximate percentage of sugar in the urine from the character of the precipitate formed It is of great value, therefore to the busy practitioner, for it readily gives him a rough idea of the amount of sugar the patient is passing

Preparation of Benedict's solution —Weigh out 173 grammes of pure sodium citrate and 100 grammes of pure anhydrous sodium carbonate and dissolve them together with the aid of heat in about 700 c c of water Filter this solution Weigh out 17 3 grammes of pure crystallized copper sulphate and dissolve separately in about 100 c c of distilled water Mix the two solutions with constant stirring and when cold make it up to 1 litre

Things required for sugar test —

(*i*) Test tubes (hard glass)
(*ii*) Medicine dropper
(*iii*) Five c c measuring cylinder
(*iv*) Benedict's qualitative reagent
(*v*) Spirit lamp

Measure out 5 c c * of Benedict's solution by means of the measuring cylinder and pour it into a test tube By means of the medicine dropper, take out the urine and put 8 drops into the test tube and boil it over the spirit lamp for about one minute or immerse the tube in boiling water for about 3 minutes

If the solution remains clear, it should be assumed that there is no excess of sugar

But if there is a precipitate, it is evidence of reduction of the copper by the sugar the quantity of which depends on the colour of the precipitate Thus —

A pea green opacity represents about 0 2 per cent of sugar
A distinct greenish precipitate means 0 5 per cent
A distinct greenish brown precipitate means 0 5 per cent to 1 per cent
A yellow precipitate means 1 0 per cent to 1 5 per cent
A red precipitate means 2 0 per cent or over
Above this percentage the colour of the solution gives little aid

* In the absence of the measuring cylinder, a teaspoonful and a half of Benedict's solution will do

Mode of estimation of sugar by Benedict's original method

Preparation of the solution —

Weigh out 200 grammes of pure potassium citrate and 100 grammes of anhydrous sodium carbonate and dissolve them together with the aid of heat in about 600 c c of distilled water dissolve 125 grammes of pure potassium sulphocyanide separately in about 150 c c of distilled water Mix thoroughly and filter if necessary Weigh out 18 grammes of pure crystallized copper sulphate and dissolve separately in 100 c c of distilled water and pour this into the other solution slowly small quantities at a time with constant stirring Add 5 c c of 5 per cent potassium ferrocyanide and then distilled water to make the total volume 1 000 c c

Method of analysis

If the qualitative test indicates a low percentage of sugar the urine may be used undiluted otherwise 10 c c of the urine should be diluted to 100 c c and this solution used for titration

The urine diluted or undiluted is poured into a 25 c c or 50 c c burette up to the zero mark Twenty five c c of the Benedict's quantitative reagent are measured by a pipette into 250 c c beaker or flask in which 3 to 4 grammes of anhydrous sodium carbonate is then added A few glass beads or pumice stone may be kept in the flask to prevent frothing and bumping The Benedict's solution with the added sodium carbonate in it is then heated over a flame till all the carbonate is in solution The urine is now run in from the burette till a bulky chalk white precipitate forms and the blue colour of the Benedict's solution lessens perceptibly in intensity From this point the solution from the burette must be run in *very slowly* a few drops at a time until the last trace of the blue colour entirely disappears It should be noted that the solution must be kept constantly boiling throughout the entire titration

Calculation

Twenty five c c of Benedict's solution is reduced by exactly 0 05 gramme of glucose, therefore, the percentage of sugar in the undiluted urine would be $\frac{0.05}{x} \times 100$ where x denotes the number in c c of the undiluted urine required to effect the titration In the case where diluted urine is used the result has to be multiplied by 10

Albumin in urine

The urine should be filtered quite clear and must be acid in reaction

Nitric acid test —Pour nitric acid into a test tube to a depth of ½ inch incline the tube nearly horizontal and slowly run about double

the quantity of urine down the side of the tube Gently bring the tube to vertical position A white deposit immediately above the acid in the shape of a clear ring indicates albumin

N B—Compound proteins (albumoses or nucleo-albumin or mucin) also gives a ring, but it appears a short distance above the nitric acid layer and is rather diffused If there is any doubt, it is best to have it verified by special confirmatory tests

Salicyl sulphonic acid test—If the urine is alkaline make it faintly acid by adding 10 per cent solution of acetic acid drop by drop If the urine is cloudy, filter it

Take 5 c c of urine each in two narrow test tubes Add 4 or 5 drops of a 20 per cent solution of salicyl sulphonic acid in one of them If small amounts of albumin are present an opalescent cloudiness appears, which can be compared with the untreated urine in the control tube If large amounts are present a pronounced turbidity or a heavy precipitate forms

*Saccharine test**—The reagent used for the test is a saturated solution of saccharine in water and is performed in the same way as the Heller's test, over which it possesses certain advantages in that it does not precipitate mucin, urea and urates

Ketones (acetone bodies) in urine.

Rothera's test—Take about 2 inches of urine in a test tube and saturate it with crystals of ammonium sulphate Add about 5 or 6 drops of freshly prepared 10 per cent solution of sodium nitro-prusside Shake gently Carefully add liquor ammonia fortis on the top of this solution If acetone is present, a violet colour appears which slowly or quickly changes to a deep permanganate colour according as the amount of acetone present is small or large This test gives a reaction with diacetic acid as well

Gerhardt's test for diacetic acid—To about 1 inch of urine in a test tube add a few drops of 10 per cent solution of ferric chloride A precipitate of ferric phosphate occurs first but on addition of a few drops more of ferric chloride, the precipitate dissolves If it does not dissolve filter the urine The development of a port wine colour indicates the presence of diacetic acid

This test is not given by acetone but it should be remembered that salicylates and carbolic acid might give a positive test but the red colour does not disappear by boiling

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* This simple test was first discovered and described by the late Dr Chunilal Bose, C I E, I S O, in *The Indian Medical Gazette* (Vol LXIV, p 17, Jan 1929) and give fairly reliable results and is recommended as a valuable bed-side method

Other reducing substances in the urine—identification of glucose by fermentation and other tests

When glucose is present in the urine in abnormal amounts, its detection by any of the well known methods is a simple matter It is only when sugar is present in small quantities, so as to give a 'doubtful reaction by the reduction tests that great difficulty is sometimes experienced in determining whether the reduction in the copper is due to the presence of sugar or to other reducing substances sometimes present in the urine We know that the substances present in the urine which may reduce copper salt (and often mistaken for sugar) are many and among others the following may be mentioned —

(1) Some of the normal constituents of the urine such as uric acid creatinine, etc, which, when present in excess, reduce copper solutions like sugar

(2) Conjugated glycuronates which are hydrolyzed to reducing substances by the alkalies, especially NaOH present in the copper reagents for sugar

(3) Carbohydrates other than glucose such as lactose, lævulose, maltose, pentose, etc

(4) Certain drugs eliminated by the kidneys such as chloral, chloroform, morphine, copaiba, salicylates, benzoic acid sulphonal, salol, turpentine, etc

(5) Homogentisic acid* present in alkaptonuric urine

The determination of the question whether the reducing substance present in the urine is glucose or any of the other substances just described is often a difficult matter There are many reagents for detection of sugar such as Fehling's, Benedict's, Nylander's etc The author has described the merits and demerits of these reagents in one of his papers published about 22 years ago† Without going

* Bose, J P, and Ghose, S, *Indian Med Gaz* 1929 Vol LXIV, p 61

† Reducing substances in the urine Their detection and identification, *The Indian Medical Gazette*, Vol LXI, April, 1926

into details it would be sufficient to say that Benedict's test has been found to be of more value than any of the other reduction tests for sugar This test however, does not differentiate between glucose and other forms of sugar

If there is doubt as to whether the reducing substance is sugar or not the simplest course is to proceed as follows —

(1) First a preliminary Benedict's test is done to see if there is any reduction of copper, indicated by the formation of a definite *precipitate* of cuprous oxide (Cu_2O)

(2) In the case of a doubtful reduction proceed by way of fermentation by Brewer's yeast Either a small Einhorn fermentation tube or even a ureometer will do for the purpose

To perform the fermentation test roughly in the consultation room add a small quantity of acid tartaric to the urine (to prevent putrefaction) *Take the specific gravity of the urine and add some baker's yeast* to it and leave it in a warm place for 24 hours Take the specific gravity of the urine again next day and if there is no appreciable reduction in the specific gravity, it may be assumed that *glucose* is not present

(3) Follow up by special confirmatory tests if necessary

The fermentation test is a very reliable test If it yields negative results that is if there is no evolution of CO_2 and no reduction of the specific gravity, it conclusively proves that the reducing substance present is not glucose but may be any of the other varieties including the drugs described above It may also be lactose pentose or glycuronic acid

If, however, the test is positive it indicates the presence of sugar—either glucose lævulose or maltose In that case the strong presumption is that glucose is present in the urine, because the other two sugars fermentable by yeast rarely occur in the urine by themselves and if present they are usually accompanied by glucose as well To make it doubly sure an osazone test for maltose and a special test for lævulose may be done separately

APPENDIX.

A

Hygiene for Diabetic Patients

Physical exercise.—It should always be remembered that physical exercise definitely improves the carbohydrate metabolism in suitable cases of diabetes. The value of physical exercise as a prophylactic measure in diabetes is also undoubted in the light of the present-day research.

Avoidance of mental worries.—It should be borne in mind that mental worry increases the blood sugar and causes increased sugar excretion in the urine and hence should be avoided as much as possible. An occasional relaxation in the shape of a trip to the hills or other pleasure resorts often helps to bring about a great improvement in the physical condition of the diabetic patient.

Avoidance of over weight.—Over weight is very undesirable for diabetic patients and it should be the endeavour of every patient to maintain a normal weight according to his age and height. Joslin's remark that diabetes is a penalty to obesity seems very appropriate.

Avoidance of infections.—Infections of any kind definitely lowers the carbohydrate tolerance in a diabetic patient and visibly increases the severity of the disease. Always beware of such infections as carbuncles, gangrene, abscesses, lobar pneumonia, etc. and report to your physician immediately.

Avoidance of oral sepsis.—Scrupulous care of the teeth and the oral hygiene is essential for diabetic patients. The ill effects of pyorrhœa and the absorption of pus therefrom certainly retard the progress of the treatment and may sometimes produce a dangerous condition in diabetic patients.

Avoidance of skin infections.—Diabetics should take great care of their skin. They should keep it scrupulously clean and should be very careful of cuts and bruises however simple they may be.

Avoidance of constipation.—Diabetics must particularly avoid constipation. If the vegetables in the diet and abdominal exercises fail to bring about normal bowel action, he should resort to mild laxatives but avoid drastic purgatives.

B

Average Weight of *Males* According to Age and Height

Height	5 0"		5 1"		5 2"		5 3"		5 4"		5 5"		5' 6"		5 7"		5 8		5 9"		5 10"		5' 1'		6 0		6 1"		6 2"		6 3"		6 4"	
Ages	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb	St	Lb
15–16	7	9	7	11	8	0	8	3	8	6	8	10	9	0	9	4	9	8	9	12	10	2	10	7	10	12	11	3	11	8	11	13	12	4
17–18	7	13	8	1	8	4	8	7	8	10	9	0	9	4	9	8	9	12	10	2	10	6	10	11	11	4	11	7	11	12	12	3	12	8
19–20	8	3	8	5	8	8	8	11	9	0	9	4	9	8	9	12	10	2	10	6	10	10	11	1	11	6	11	11	12	2	12	7	12	12
21–22	8	6	8	8	8	11	9	0	9	4	9	8	9	12	10	1	10	5	10	9	10	13	11	0	11	8	11	13	12	4	12	9	13	0
23–24	8	8	8	10	8	13	9	2	9	6	9	10	10	0	10	3	10	7	10	11	11	1	11	5	11	10	12	1	12	7	12	12	13	3
25–27	8	10	8	12	9	0	9	3	9	7	9	11	10	1	10	5	10	9	10	13	11	3	11	8	11	13	12	5	12	11	13	2	13	7
28–30	8	13	9	1	9	3	9	6	9	9	9	13	10	3	10	7	10	11	11	1	11	5	11	10	12	2	12	8	13	0	13	6	13	11
31–33	9	1	9	3	9	5	9	8	9	11	10	1	10	5	10	9	10	13	11	3	11	6	11	13	12	5	12	11	13	3	13	9	14	1
34–36	9	2	9	4	9	6	9	9	9	12	10	2	10	6	10	10	11	1	11	6	11	11	12	2	12	9	13	0	13	6	13	12	14	4
37–39	9	3	9	5	9	7	9	10	10	0	10	4	10	8	10	12	11	3	11	8	11	13	12	4	12	10	13	2	13	9	14	1	14	7
40–42	9	5	9	7	9	9	9	12	10	1	10	5	10	9	10	13	11	4	11	9	12	0	12	6	12	12	13	4	13	11	14	4	14	10
43–45	9	6	9	8	9	10	9	13	10	2	10	6	10	10	11	0	11	5	11	10	12	1	12	7	12	13	13	5	13	12	14	5	14	12
9	9	8	9	10	9	12	10	1	10	4	10	8	10	12	11	2	11	7	11	12	12	3	12	9	13	1	13	7	14	0	14	7	15	0
		8	0	10	9	12	10	1	10	4	10	8	10	13	11	2	11	7	11	12	12	3	12	9	13	1	13	8	14	1	14	8	15	1

Average Weight of *Females* According to Age and Height

Height	4 8″	4 9	4 10″	4 11″	5 0	5 1″	5 2″	5 3″	5 4″	5 5″	5 6″	5 7″	5 8″	5 9″	5 10″	5 11″	6 0″
Ages	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb	St Lb
15–16	7 3	7 5	7 7	7 8	7 9	7 11	8 0	8 3	8 6	8 8	9 0	9 4	9 8	9 12	10 2	10 7	10 12
17–18	7 5	7 7	7 9	7 11	7 13	8 1	8 4	8 7	8 10	8 13	9 3	9 7	9 11	10 0	10 4	10 9	11 0
19–20	7 7	7 9	7 11	7 13	8 1	8 3	8 6	8 9	8 12	9 1	9 5	9 7	9 13	10 2	10 6	10 11	11 1
21–22	7 9	7 11	7 13	8 1	8 3	8 5	8 6	8 11	9 0	9 3	9 7	9 11	10 1	10 4	10 8	10 12	11 2
23–24	7 10	7 12	8 0	8 2	8 4	8 6	8 9	8 12	9 1	9 4	9 8	9 12	10 2	10 6	10 10	10 13	11 3
25–27	7 11	7 13	8 1	8 3	8 5	8 7	8 9	8 12	9 2	9 5	9 9	9 13	10 3	10 7	10 11	11 0	11 4
28–30	7 13	8 1	8 3	8 5	8 7	8 9	8 11	9 0	9 4	9 7	9 11	10 1	10 5	10 9	10 13	11 2	11 6
31–33	8 1	8 3	8 5	8 7	8 9	8 11	8 13	9 2	9 6	9 9	9 13	10 3	10 7	10 11	11 0	11 3	11 7
34–36	8 3	8 5	8 7	8 9	8 11	8 13	9 1	9 4	9 8	9 12	10 2	10 6	10 10	11 0	11 3	11 6	11 9
37–39	8 4	8 6	8 8	8 10	8 12	9 0	9 3	9 6	9 10	10 0	10 4	10 8	10 12	11 2	11 5	11 8	11 11
40–42	8 7	8 9	8 11	8 13	9 1	9 3	9 6	9 9	9 12	10 2	10 6	10 10	11 0	11 4	11 7	11 10	11 13
43–45	8 9	8 11	8 13	9 1	9 3	9 5	9 8	9 11	10 0	10 4	10 8	10 12	11 2	11 6	11 9	11 13	12 2
46–49	8 11	8 13	9 1	9 3	9 5	9 7	9 10	9 13	10 1	10 6	10 10	11 0	11 4	11 8	11 11	12 1	12 4
50	8 13	9 1	9 3	9 5	9 7	9 9	9 12	10 1	10 4	10 8	10 12	11 2	11 7	11 11	12 1	12 5	12 8

C

A Few Useful Recipes for Diabetic Patients

Broths and soups

Broths and soups are very useful for diabetic patients because their food values are comparatively small while their bulk is fairly large and thus they are *filling to the stomach and satisfying to the appetite*

Clear soups may be made in the ordinary way from stock Thick soups can be made with stock or water as a basis and various kinds of vegetables may be added to it which will thus give it substance and make it palatable without much increase in the food values Vegetables such as chopped cabbages celery string beans onions etc may be used

(1) *Clear soup*

Brown stock	8 oz
Onions	2
Celery	2 sticks
White of 2 eggs	
Seasonings	

Remove fat from stock and put into a clean pan Add the vegetables cut up in thin slices Beat white of eggs to a stiff froth and add Bring the mixture to boil slowly whisking occasionally while boiling Simmer for 10 minutes and strain through muslin Add salt and seasonings and reboil before serving

Food values—C = 7 P = 8 F = negligible

(2) *Tomato soup*

Stock
Tomato
Cream
Onion

Cut the tomatoes in pieces and cook it in stock until quite soft, then rub through a fine sieve rejecting the seeds and skin Add seasonings and bring it to boil Add cream just before serving

Food values—C=10, P=2, F=4

Sauce and Mayonnaise Dressings

(3) *Cheese sauce*

Yolk of one egg	
Butter	½ oz
Grated cheddar cheese	½
Seasonings	

Beat up the yolk of the egg thoroughly, add seasonings and cheese Melt butter in a sauce pan and put the mixture in it bringing it to boil slowly, stirring all the time

Food values—C=0, P=8, F=25

(4) *Cream sauce*

Butter	1 level teaspoonful
Flour	1 " "
Cream	1 oz
Water	1 "
Salt	

Melt the butter add flour and salt and mix until perfectly smooth Add cream and water and cook for a few minutes

Food values—C=3, P=1, F=15

(5) *Diabetic mayonnaise*

Egg	1
Mustard	1½ teaspoonfuls
Salt	
Saccharine	½ grain
Mineral oil	8 to 10 oz
Lemon juice	

Beat egg thoroughly Add the dry ingredients gradually, beat well and add lemon juice Add mineral oil slowly drop by drop beating constantly Thin with lemon juice or white vinegar

Food values—A small quantity of this dressing has practically no food value

(6) *French dressing*

White vinegar	1 tablespoonful
Olive oil	1 ,
Salt and pepper	

Mix ingredients and stir until thoroughly mixed

Food values—C=0 P=0 F=15

Custard Puddings

(7) *Baked custard*

Egg	1
Milk	4 oz
Saccharine	

Beat egg well and add milk sweetened with saccharine, a little at a time Pour the mixture into a dish and bake in a moderate oven for about 15 to 20 minutes

Food values—C=5 P=9 F=9

(8) *Almond custard*

Milk	3½ oz
Yolk of one egg	
Ground almonds	½ oz
Cinnamon	
Saccharine	
Lemon rinds	

Boil the milk with cinnamon and some pieces of lemon rinds for about 5 minutes Strain and when it cools down

Cut the tomatoes in
quite soft, then rub thro
and skin Add seasonin
just before serving

Food valu

SAUCE AND

Yolk of on
Butter
Grated h
Seasonin

Beat up the
and cheese Mel
in it bringin

I

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Melt the
perfectly smoo
minutes

Food

(5) I

Egg
Mustard
Salt
Saccharine
Mineral oil
Lemon juice

(11) *Chhana chapatis* *

Wheat flour	2 oz †
Chhana (dry)	2
Ghee	2 teaspoonfuls
Salt	(to taste)

Mix chhana with flour well together preferably with the hand Add ghee and mix thoroughly again And water gradually and make into a firm dough Divide into 3 or 4 pieces and put it on a well floured rolling board and roll it evenly

Bake on an oven and make Chapatis in the usual way

Food values—C = 42 P = 18 F = 15

* This is recommended for the vegetarian diabetics and is sometimes found to be useful in supplementing protein to their diet in a more palatable form

† Reserve a spoonful of flour for use on the rolling board for smooth rolling

to some extent add to it the beaten egg yolk ground almonds and saccharine Pour it in a cup and stand it in a sauce pan of hot water Stand the sauce pan over low gas until the mixture begins to thicken Stir all the time

Food values—C=7 P=7, F=13

Ice Creams

(9) *Chocolate ice cream*

Cocoa	1 teaspoonful
Cream	2 oz
Water	2
Saccharine	½ gram
Vanilla	½ teaspoonful

Cook the cocoa in water cool and add cream saccharine and flavourings Freeze

Food values—C=4 P=2 F=10

(10) *Diabetic marmalade*

Peel of orange	One (large)
Lemon (large)	One
Saccharine	4 grains
Water	6 ounces
Gelatine *leaf*	½ ounce

Peel one large orange wash the skin thoroughly and cut in very small pieces Peel the lemon and cut the skin in the same way Mix and chop the two together finely *Add the juice of the lemon and the water* Bring it to a boiling point and simmer for an hour or more adding water whenever necessary to replenish the water lost through boiling Cut gelatine into strips and add *it along with* the saccharine Stir for 10 minutes and put it in a jar to set

This is practically of no food value

APPENDIX II

A

Approximate amount (in grammes of carbohydrate Protein, Fat and Calories yielded by one ounce (approximately ½ chittack) of common food stuffs

Food values (gms per oz)

Food stuffs	Carbo-hydrate	Protein	Fat	Calories
Cereal Products				
Arrowroot	25 0	0 1		100
Bajri	19 4	3 2	1 5	109
Barley (raw)	20 6	3 0	0 3	99
(Pearl)	22 0	2 1	0 3	101
Bread (white)	16 0	2 3	0 2	75
(white toasted)	20 0	2 7	0 3	89
(brown)	15 2	2 4	0 4	70
Cambu	19 4	3 6	1 3	105
Chira (beaten rice)	22 1	1 9	0 4	106
Cornflour	26 2	0 1	0 2	101
Khoi (fried paddy)	21 0	2 1	traces	100
Macaroni (raw)	22 1	3 5	0 4	102
Maize tender (*bhutta kancha*)	4 2	1 2	traces	25
(*Makai dry*)	18 7	3 1	1 0	102
Makhna	21 8	2 7	traces	101
Muri (puffed rice)	20 4	1 8	0 3	90
Oatmeal (raw)	19 0	3 4	1 5	115
„ (porridge)	2 3	0 4	0 3	13
„ (Scotch)	20 1	3 6	1 8	112
Oats, rolled (quaker)	18 8	4 5	2 1	115

D

Table of Approximate Equivalents

Household fluid measures

1 teaspoonful corresponds to ⅛ oz or 3 5 c c
1 dessertspoonful corresponds to ¼ oz or 7 c c
1 tablespoonful corresponds to ½ oz or 15 c c
1 egg cupful corresponds to 1 oz or 30 c c * or ½ *chittack*
1 wine glassful corresponds to 2 oz or 1 *chittack*
1 teacupful corresponds to 6 oz or 3 *chittacks*
1 tumblerful corresponds to 8 oz or 1 *pow*

Imperial weights and measures

1 fluid oz corresponds to 30 c c *
35 fluid oz (1¾ pints) correspond to 1,000 c c (1 litre) or 1 *seer* and 1½ *chittacks*
160 fluid oz (8 pints or 1 gallon) correspond to 4½ litres or 5 *seers*
1 oz corresponds to 30 gm † or 2½ *tolas* (1 *tola* = ⅜ oz)
2 oz correspond to 1 *chittack* (5 *tolas*)
1 pound corresponds to 450 gm or ½ *seer* (1 *seer* = 928 gm)
2⅛ lb (35 oz) correspond to 1 000 gm (1 kilo) or 1 *seer* 2½ *chittacks*
1 stone (14 lb) corresponds to 6⅓ kilos or 6⅞ *seers*

Conversion factors

To convert ounces into grammes multiply by 28 35
To convert pounds into kilogrammes multiply by 0 453
To convert grammes into ounces multiply by 0 035
1 silver rupee weighs 1 tola or 11 36 gm or ⅖ oz approximately
1 four anna bit weighs 2 84 gm or 1/10 oz approximately
1 Indian bazaar seer weighs 80 tolas or 928 gm or 32⅔ oz approximately

Caloric value of food stuffs

1 gramme of carbohydrate yields 4 1 calories
1 gramme of protein yields 4 1 calories
1 gramme of fat yields 9 3 calories
1 c c of alcohol yields 5 6 calories

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* Actually 28 35 c c
† Actually 28 35 gm

APPENDIX II (A)—*(continued)*

Food stuffs	Carbo-hydrate	Protein	Fat	Calorie
Cereal Products—*contd*				
Force	3.8	2.6	0.5	105
Grape-nuts	21.4	3.4	0.9	102
Shredded wheat	22.4	2.8	0.8	103
Lentils (dry)				
Besan (powdered dal)	16.5	6.4	0.9	102
Lobia (cow gram)	15.8	7.0	0.2	101
Dal (average)	15.9	6	0	100
(arhar) red gram	16.2	6.3	0.5	104
(chola) Bengal	17.0	4.9	1.5	112
(Khessari)	16.5	8.0	0.2	10
(krishna mung)	15.8	6.3	0.4	94
(matar)	16.1	5.6	0.3	96
(Mussor)	16.9	7.1	0.2	105
(sona mung)	16.0	6.8	0.4	102
Gram roasted *(bhaja chola)*	16.8	6.4	1.5	119
whole *(chola)*	17.3	4.8	1.5	109
Haricot beans	17.9	6.1	trace	3
Matar Kabli (dry peas)	16.0	6.0	trace	96
Soya bean (flour)	4.0	11.5	6	123
Sattoo (powdered gram)	17.1	7.6	0.6	107
Milk and Milk Products				
Butter (fresh)	0.0	0.1	24.0	218
Butter milk *(ghol)* unsweetened	0.4	0.8	traces	88
Chhana (fresh milk curd)	0.1	6.0	5.0	[illegible]

APPENDIX II (A)—(*continued*)

Food stuffs	Carbo hydrate	Protein	Fat	Calories
Cereal Products—*contd*				
Rice (average)	24 5	1 4	0 2	104
,, beaten (*chira*)	22 1	1 9	0 4	106
,, boiled (*bhat*)	10 4	0 6	traces	45
,, fried paddy (*khoi*)	21 0	2 1	traces	100
,, Old (*dadghani*)	24 0	1 5	traces	108
,, parboiled home pounded (*siddha*)	22 0	2 4	traces	106
,, puffed (*muri*)	20 4	1 8	0 3	90
,, raw home-pounded (*atap*)	22 2	2 4	traces	102
,, raw milled	22 5	2 0	0 2	102
Rusk (plain unsweetened)	18 7	4 5	2 5	116
Sago	26 7	0 1	traces	101
Sooji (semolina)	15 0	4 2	0 6	80
Tapioca	27 0	0 2	traces	102
Vermicelli	21 0	3 0	0 5	100
Wheat flour refined (*maida*)	21 5	2 8	0 3	103
Wheat flour (*atta*)	20 8	3 3	0 5	102
Whole wheat (*gehu*)	20 1	3 3	0 5	102
Wheat gluten	0 4	6 3	traces	28
Biscuit (average)	21 0	2 1	3 8	120
,, (cream cracker)	16 3	2 4	9 4	158
,, (digestive)	18 7	2 7	5 8	137
Biscuit (sweet mixed)	18 9	1 6	8 7	158
,, (vita weat)	22 1	2 4	2 9	120
,, (water)	20 7	3 0	3 5	176
Bun	16 2	2 3	1 7	87

APPENDIX II (A)—(*continued*)

Food stuffs	Carbo hydrate	Protein	Fat	Calories
Green Vegetables				
Green vegetables (average)	1·4	0·2	traces	5
Asparagus (*soot moolee*)	0·7	0·7	traces	6
Beans, broad (*seem*)	2·8	1·3	traces	17
Beans string (*barbati*)	1·7	0·7	traces	11
Betel leaves (*pan*)	1·7	0·9	traces	13
Brinjal (*baigun*)	1·8	0·4	traces	10
Brussels sprouts (*choti banda kobi*)	1·2	0·6	traces	15
Cabbage (*banda Kobi*)	1·4	0·3	traces	9
Cauliflower (*phool kobi*)	0·8	0·5	traces	9
Celery (*shalarri*)	1·5	0·5	traces	9
Cucumber (*khira sosha*)	0·8	traces	traces	4
Drum stick (*sajina data*)	0·8	0·7	traces	9
Endive (*kasni leaves*)	0·7	traces	traces	6
French beans	1·3	0·5	traces	8
Gourd, Ash (*chhachi kumra*)	0·9	traces	traces	5
,, bitter, large (*karela*)	1·2	0·5	traces	8
,, bitter small (*ucchay*)	2·7	traces	traces	18
,, bottle (*lau kaddu*)	0·8	traces	traces	4
,, club (*dhundul*)	1·0	0·2	traces	5
,, Sponge (*jhinga*)	0·4	traces	traces	
,, snake (*chichinga*)	1·0	0·1	traces	5
,, white (*chaul kumra*)	0·9	traces	traces	4
Jack fruit unripe (*inchar*)	2·7	0·7	traces	15
seeds (kantalbij dry)	10·9	1·9	traces	53
Lady's finger (*dhanrosh bhindee*)	2·0	0·6	traces	12

APPENDIX II (A)—(*continued*)

Food stuffs	Carbo-hydrate	Protein	Fat	Calories
Milk and Milk Products—*contd*				
Cheese (American) ..	0.3	8.1	10.1	128
,, (Cheddar)	traces	7.1	9.8	119
,, (Dutch)	traces	8.0	4.8	77
,, (cream)	traces	0.9	24.5	232
,, (*Gorgonzola*)	*traces*	*7.1*	*8.8*	*112*
,, (Gruyére)	traces	10.4	9.5	131
Curds (Dahi) unsweetened	*0.9*	*0.8*	*0.8*	*16*
Ghee (Clarified butter)	0.0	0.0	25.0	228
Milk (ass)	*1.7*	*0.7*	*0.5*	*15*
,, (buffalo)	1.5	1.2	2.5	28
,, (cow)	*1.4*	*0.9*	*1.1*	*19*
,, (skimmed)	1.4	1.0	traces	11
,, (Goat)	*1.4*	*1.1*	*1.1*	20
,, (human)	2.0	0.3	1.0	18
,, (sheep)	1.8	0.6	traces	13
,, powder (whole)	10.0	7.3	8.0	146
,, powder (skim)	14.5	10.8	traces	104
,, powder ("klim")	11.0	7.6	7.6	
,, powder (Horlicks)	19.0	4.5	2.6	114
,, malted (average)	21.3	3.6	2.0	121
,, malted (Horlick)	20.1	4.1	2.4	114
Milk condensed, whole (unsweetened)	3.5	2.2	2.4	44
,, condensed, whole (sweetened)	15.9	2.3	3.4	*100*
,, Khoa (*khoa khir*)	5.8	4.1	8.8	124
,, Whey	1.4	0.2	traces	8

APPENDIX II (A)—(*continued*)

Food stuffs	Carbo-hydrate	Protein	Fat	Calorie
Tubers and Root Vegetables				
Artichoke (*hathichuk*)	4.5	1.0	traces	23
Beet (*chukander*)	4.0	0.5	traces	18
Carrot (*gajar*)	2.5	0.3	traces	13
Knol Kole (*ole kobi*)	1.7	0.3	traces	8
Leeks (*bilati piaj*)	2.9	0.5	traces	14
Mankachu	5.5	0.2	0.4	28
Ole	3.6	0.6	0.8	21
Onion (*piaj*) big	3.3	0.3	traces	16
" , small	3.8	0.5	traces	18
Onion stalk (*piaj kali*)	2.5	0.3	traces	12
Parsnips	3.2	0.4	traces	14
Pepper Green (*kancha lanka*)	1.7	0.8	traces	12
Potatoes (*alu*)	5.5	0.5	traces	25
"Chips"	10.6	1.1	2.6	68
" boiled	5.3	0.7	traces	27
" New	5.0	0.5	traces	22
" Sweet (*ranga alu*)	8.8	0.3	traces	38
Raddish (*moola*), pink	2.1	0.2	traces	10
" , white	1.2	0.2	traces	6
Shankalu	6.2	0.4	traces	27
Turnip (*shalgam*)	2.2	0.1	traces	10
Yam (*kachu*)	6.0	0.4	traces	23
Fresh Fruits				
Amla (*amloki*)	4.2	0·1		17
Apples (ordinary)	3.8	0.1	traces	15

APPENDIX II (A)—*(continued)*

Food stuffs	Carbo-hydrate	Protein	Fat	Calories
Green Vegetables—*contd*				
Lettuce (*saladh*)	0 6	0 6	traces	7
Mango, green	2 5	0 2	traces	12
Mint (*pudina*)	2 2	1 3	traces	16
Mushroom	2 0	1 0	0 1	13
Papaya, green	0 1	0 2	traces	2
Patal (*pulval*)	0 6	0 5	traces	6
Peas, green (*kalai suti*)	5 6	2 0	traces	32
Pepper green (*kancha lanka*)	1 7	0 8	traces	10
Plantain flower (*mocha*)	1 4	0 4	traces	8
" green (*kancha kala*)	4 2	0 2	traces	18
" stem (*thor*)	2 7	0 1	traces	12
Pumpkin, red (*kumra*)	2 0	0 3	traces	8
Rhubarb	1 0	0 1	traces	5
Sag (*dhania*) coriander leaves	1 9	0 9	0 2	13
" (*kalmi*)	1 2	0 5	traces	8
" (*kochu*)	1 2	0 1	traces	6
" (*notay*) dwarf spinach	0 9	0 4	traces	6
" (*palong*) Indian spinach	1 1	0 6	traces	9
" (*poyee*) Malabar night shades	0 3	0 3		
Sag (*palta*)	0 3	1 4	traces	6
" (*pudina*) Mint	2 2	1 3	traces	16
" (*sarsey*) Rape plant stem	1 1	0 9	traces	6
Tomato (*bilati baigun*)	1 2	0 4	traces	7
Vegetable marrow (*bilati kumra*)	1 1	0 1	traces	6

\PPE\DI\ II (\)—*(continued)*

I ood stuffs	Carbo-1 drate	Prote n	I at	Calor es
Fresh Fru ts—*co td*				
Ie o usk (*rl a b ja*)	2 0	0 6	traces	8
ater *l b j*)	1 1	traces		5
)ra ge (*ka ala cb*)	2 4	0 ?	traces	10
)range ju ce	2 7	0 ?	tra e	11
almyra fru t (*tal sl a*)	1 9	0 1		9
a (pl al water cl e tnut)	6 8	1 3	traces	34
apaya (r pe or 1 nar)	2 7	0 1	traces	1?
(be t I an 1	3 5	0 ?	traces	15
eacl es (fresl)	2 6	0 2	traces	11
ears countr (*a pat*	3 3	0 1	trace	14
Engl l	3 0	0 1	traces	11
neapple (*ana as*)	3 ?	0 1	trace	14
'lun *kool*	2 7	0 ?	traces	11
re l var et	2 1	0 ?	traces	10
megranat (*Da*)	0 6	0 ?		4
(*Be la*)	3 3	0 1	trace	13
'u el (*balab eb*	2 9	0	traces	13
o eberry (*golabja*	1 4	0 4	traces	7
rawl err	1 8	0 ?	traces	7
ugarcane	6 6	0 4	traces	?7
Tamar n l r pe (*te t l I e*)	8 8	0 4	traces	37
T matoes r pe	1 ?	0 4	traces	7
Dr ed Fru ts				
A| r cot (*kl oba*)	1? 3	1 6	traces	52
D. es (*khefu*) Per 1 be t	18 1	0 6	traces	0

APPENDIX II (A)—(*continued*)

Food stuffs	Carbo-hydrate	Protein	Fat	Calor
Fresh Fruits—contd				
Banana (*singapuri*)	6 1	0 3		2
,, (*chatim kela*)	5 0	0 3		20
,, (*champa kela*)	4 2	0 3		1[illegible]
Bael	4 5	0 2	traces	21
,, (*kayet*) wood apple	4 3	2 0	traces	28
Blackberry (*kalajam*)	1 0	0 4	traces	8
Bullock's heart (*amra*)	5 9	0 4	traces	26
Coco nut water (*dab pani*)	0 7	0 4		5
,, Kernel (*narkel*)	3 9	1 7	15 1	134
Cucumber (*sasha khira*)	0 5	traces	traces	3
Figs	4 8	0 4	traces	12
Gooseberry (*tepari*)	3 3	0 3		15
Grapes (white) *Angoor*	4 6	0 2	traces	18
,, (black variety)	4 4	0 2	traces	17
Grape fruit	1 5	0 2	traces	6
Guava (*peara Deshi*)	2 0	0 2	traces	12
,, (,, Kashi)	3 3	0 3	traces	15
Jack fruit (*kantal*)	5 5	0 4	traces	25
Lemon (*pati nimbu*)	2 3	0 2	traces	12
Lichee (*lichu*)	2 0	0 8	traces	11
Lime, sweet (*sarbati nebu*)	3 6	0 3	traces	14
Loquat (*loket*)	1 5	traces	traces	6
Mango ripe (*Deshi*)	3 6	0 2		15
,, (*langrah*)	5 1	0 5		24
(*Bombay*)	5 4	0 5	traces	26
Melon (*footee*)	1 4	0 2	traces	6

APPENDIX II (A)—(*continued*)

Foodstuffs	Carbo-hydrate	Protein	Fat	Calories
Condiments, Spices, etc.—*contd*				
Mustard (rai)	6.8	6.3	11.3	159
Nutmeg (*jaiphal*)	8.1	2.1	10.3	138
Omum (*ajwan*)	11.5	4.5	5.4	113
Pepper, dry (*gol morich*)	14.1	3.3	1.9	91
Tamarind, ripe (*Tentul*)	8.8	0.4	traces	37
green	2.2	0.4		13
Turmeric (*haldi*)	1.8	1.7	1.4	28
Eggs				
Egg, duck (whole)	0.0	3.8	3.8	52
(white)	0.0	2.6	traces	11
Egg (yolk)	0.0	4.6	8.7	99
,, hen (whole)	0.0	3.6	3.6	50
Fish				
Crab (muscle)	1.0	2.5	0.3	17
Fish (*average*)	0.0	5.5	1.0	32
,, *Beleh*	0.0	4.1	0.1	18
,, *Bhangor*	0.0	4.1	2.4	40
Bhetki	0.0	4.2	0.6	25
Herrings (salted)	0.0	4.2	4.2	58
Hilsa (fish)	0.0	6.2	5.5	77
Katla	0.0	5.5	0.7	20
Koi	0.0	6.1	0.1	26
Lala	0.0	5.3	0.1	24
Magur	0.0	5.5	0.2	21
Mango (*tapsi*)	0.0	4.7	1.2	31

APPENDIX II (A)—(*Continued*)

Food stuffs	Carbo-hydrate	Protein	Fat	Calories
Dried Fruits—*contd*				
Figs dried (*Anjeer*)	15 0	1 0	traces	61
Prunes	11 5	0 7	traces	46
Raisins (*kismis*)	18 3	0 3	traces	70
NUTS				
Almonds (*kagji badam*)	3 0	5 9	15 2	170
Brazil nuts	2 1	5 1	17 3	183
Cashew nuts (*kaju badam*)	6 3	6 0	13 3	174
Chestnuts	10 4	0 7	0 8	49
Coco-nut kernel	3 9	1 7	15 9	134
Peanut (*china badam*)	5 7	7 5	11 4	160
,, roasted	5 5	9 0	11 3	165
Pistachio nuts (*pesta*)	4 6	5 6	15 2	183
Walnuts (*akrote*)	3 1	4 4	18 3	199
Condiments, Spices, etc				
Asafoetida (*hing*)	19 2	1 1	0 3	90
Cardamom (*alaich*)	11 9	2 8	0 6	70
Chillies green (*Kancha lanka*)	1 8	0 8	0 2	12
dry (*sukna lanka*)	8 9	4 5	1 7	74
Cloves (*labanga*)	13 6	1 5	2 5	87
Coriander (*dhane*)	6 2	4 0	4 6	86
Cumin (*jira*)	10 3	5 3	4 2	106
Fenugreek seeds (*methi*)	13 0	7 8	1 5	90
Garlic (*rasun*)	8 2	1 8	traces	43
Ginger (*ada*)	3 5	0 7	0 3	20
Mace (*jaitri*)	14 1	1 8	7 2	131

APPENDIX II (A)—(*continued*)

Food stuffs	Carbo-hydrate	Protein	Fat	Calories
Meat—*contd*				
Pigeon	0.0	6.2	1.8	42
Pork	0.0	6.0	3.1	53
Sheep's kidney	traces	4.7	1.3	31
,, liver	0.5	5.4	2.1	44
Tongue (sheep)	0.0	4.5	5.4	67
Turkey (roast)	0.0	5.1	1.3	34
Animal Fats and Vegetable Oils				
Cocogem	0.0	0.0	28.0	260
Cocoanut oil	0.0	0.0	28.2	262
Cod liver oil	0·0	0.0	28.4	264
Fat mutton	0.0	0.4	26.4	239
Gingelly oil (*Til*)	0.0	0.0	28.0	260
Ground nut oil	0.0	0.0	28.0	260
Lard	0.0	0.0	29.4	264
Margarine	0.0	0.0	24.2	226
Mustard oil	0.0	0.0	28.2	263
Olive oil	0.0	0.0	29.4	264
Sweets				
Bread pudding	11.4	1.8	3.2	80
Bun	16.2	2.5	1.7	87
Cherry cake	16.0	1.3	6.8	129
Chutney (tomato)	11.0	0.3	traces	43
Glucose	25.8	0.0	0.0	106
Honey (pure)	21.7	traces	traces	82
Ice cream (average)	5.0	1.1	3.8	58

APPENDIX II (A)—(*Continued*)

Food stuffs	Carbo-hydrate	Protein	Fat	Calories
Fish—*contd*				
Fish *Mourala*	0 0	5 1	1 1	32
,, *Mrigal*	0 0	5 5	0 1	24
,, Prawn (*chingree*)	0 0	5 4	0 4	26
,, *Parsheh*	0 0	4 7	1 8	35
, *Puti*	0 0	5 1	0 7	27
, *Rui*	0 0	4 7	0 4	23
,, Salmon (salted)	0 0	5 7	3 1	53
,, *Singhi*	0 0	6 5	0 1	28
, *Sole*	0 0	4 5	0 7	25
,, *Tangrah*	0 0	5 4	1 3	39
Meat				
Meat butcher's (average)	0 0	6 1	3 0	53
Bacon	0 0	3 6	14 0	144
Beef (corned)	0 0	6 4	4 3	66
,, steak raw	0 0	5 5	3 0	50
Brain	0 0	2 9	2 7	37
Chicken	0 0	6 0	1 4	43
Crab Muscle (*kankrah*)	1 0	2 5	0 3	17
Duck	0 0	5 1	2 9	51
Fowl	0 0	5 5	4 6	70
Goat meat	0 0	7 1	1 0	36
Ham (medium fat)	0 0	4 3	10 8	118
Mutton (*fat*)	0 0	4 0	9 5	105
, (lean)	0 0	5 3	2 0	42
,, (roasted)	0 0	7 1	5 6	83

APPENDIX II (A)—(*continued*)

Food stuffs	Carbo-hydrate	Protein	Fat	Calories
Miscellaneous—*contd*				
Horlick's Malted Milk	20 1	4 1	2 4	114
Liebig's extract of beef	0 0	8 6		35
Meat stew (home made)	1 5	1 3	1 2	[illegible]3
Marmite	0 0	[illegible] 8	traces	1[illegible]
Mellin's food	[illegible]	3 [illegible]	0 1	107
Ovaltine	17 4	3 7	[illegible] 2	101
Raw meat juice	0 0	0 5		[illegible]
Sandwiches chicken	9 1	3 5	1 3	64
ham	10 8	[illegible] 9	4 0	94
Virol	6 9	1 3	3 6	10[illegible]
Soup Chicken	0 6	[illegible]	0 2	16
clear	0 0	1 0	traces	5
pea	3 1	1 4	1 9	36
tomato	1 5	0 5	0 3	11

APPENDIX II (A)—(*Continued*)

Food stuffs	Carbo-hydrate	Protein	Fat	Calories
Sweets—contd				
Jaggery	27 0	0 1	traces	111
Jam	19 7	traces	traces	74
Jam tarts	18 3	1 7	5 6	128
Marmalade	19 8	traces	0 4	74
Mince pies	12 2	1 3	5 6	103
Oat meal biscuit	17 7	2 5	6 8	143
Pastry (cream)	16 4	0 4	3 2	91
Sandesh (best quality)	11 4	5 1	5 6	120
Scones (with egg)	17 0	2 4	3 0	102
Sugar (brown)	26 8	traces	traces	109
Sugar (white)	28 1	traces	traces	112
Treacle (*goor*)	25 0	traces	traces	100
Cooked Foods				
Boiled rice (*bhat*)	10 4	0 6	0 1	45
Chapati	19 6	2 6	1 0	100
Loochi (fried in ghee)	14 2	2 1	6 4	130
Paratah (cooked in ghee)	14 2	2 3	5 0	115
Miscellaneous				
Benger's food (dry)	22 8	3 4	traces	107
Blancmange	5 3	0 9	1 1	34
Bourn vita	19 2	3 2	2 1	105
Bouillon	0 0	0 2	traces	1
Bovril	0 0	8 3	0 2	36
Cocoa (dry)	10 6	5 1	7 5	134
Cocoa (powder)	9 9	5 8	6 6	128

APPENDIX II (A)—(*concluded*)

	Carbohydrate content	Calories
MINERALS		
Ginger ale (sweet) Schweppes per large bottle 11 oz	26	107
Ginger ale dry per large bottle 11 oz	20	82
Ginger bear per large bottle 16 oz	24	98
Lemonade per bottle 6¼ oz	20	78

Classified list of green and root vegetables (arranged according to carbohydrate content)

Class I

Carbohydrate content per ounce—about 1 gramme or less (equivalent to ¼ teaspoonful of sugar or less)

Asparagus (*soot moolee*)
Caul flower (*phool kobi*)
Cucumber (*sosha kh ira*)
Drum Stick (*sajna data*)
Endive (*kasni leaves*)
Gourd Ash (*chhachi kumra*)
Gourd bottle (*lau kaddu*)
Gourd club (*dhundual*)
Gourd snake (*chichinga*)
Gourd sponge (*jhinga*)
Gourd white (*chaul kumra*)
Lettuce (*saladh*)
Papaya green
Palol (*palval*)
Rhubarb
Spinach (*palong sag*)
Sag (*palla*)
Sag poyee (Malabar night shades)
Sag notay (dwarf spinach)

Class II

Carbohydrate content per ounce—about 2 grammes (equivalent to about ½ teaspoonful of sugar)

Betel leaves (*pan*)
Beans string (*barbati*)
Brinjal (*baigun*)
Brussels sprouts (*chota banda kobi*)
Cabbage (*banda kobi*)
Celery (*shalarea*)
French beans
Gourd bitter (*large karela*)
Lady's finger (*dhanrose, bhindee*)
Knol kole (*olekobi*)
Peper green (*kancha lanka*)
Plantain flower (*mocha*)
Pumpkin red (*kumra*)
Radish white & pink (*moola*)
Sag (*dhane*)
Sag (*Kalmi*)
Sag (*kochu*)
Sag (*sarse*)
Tomato (*bilati baigun*)

APPENDIX II (A)—(*continued*)

Table of Alcoholic Beverages

Alcoholic beverages	Carbo-hydrate (grammes per oz)	Calories (per oz)	Alcohol content (c c per oz)
BEERS			
Ale	1 6	17 0	1 4
Beer	1 5	15 0	1 5
Stout	2 1	21 0	2 1
LIQUERUS			
Absinthe	traces	79 0	14 2
Benedictine	9 3	109 0	12 8
Créme de menthe	7 9	108 0	13 6
Kummel	9 0	87 0	9 0
Vermouth	2 7	35 0	4 2
SPIRITS			
Brandy	0 0	71 0	12 7
Gin	0 0	48 0	8 5
Rum	0 0	68 0	12 2
Whisky	0 0	40 0	7 1
Bordeaux-claret	traces	14 0	2 5
Burgundy (average)	traces	17 0	3 1
Champagne (dry)	0 5	21 0	3 4
Claret (Italian)	0 0	17 7	3 1
Hock	0 0	12 0	2 2
Madeira	0 5	26 0	4 2
Marsala	1 0	31 6	4 8
Port	1 9	37 0	4 8
Sherry (dry)	0 5	29 0	4 8
,, (sweet)	1 0	31 0	4 8

APPENDIX II (A)—(concluded)

	Carbo-hydrate content	Calories
MINERALS		
Ginger ale (sweet) Schweppes per large bottle 11 oz	6	10
Ginger ale dry per large bottle 11 oz	20	82
Ginger bear per large bottle 16 oz	24	98
Lemonade per bottle 6 ½ oz	20	78

Classified list of green and root vegetables (arranged according to carbohydrate content)

Class I

Carbohydrate content per ounce—about 1 gramme or less (equivalent to ¼ teaspoonful of sugar or less)

- Asparagus (*soot i oolee*)
- Cauliflower (*phool kob*
- Cucumber (*sosha kh ra*
- Drum Stick (*saj a data*)
- Endive (*kas i leaves*)
- Gourd Ash (*chhachi kum ra*)
- Gourd bottle (*la kaddu*)
- Gourd clut (*[illegible] dual*)
- Gourd snake (*ch [illegible] nga*
- Gourd sponge (*jh ga*
- Gourd white (*chaul kumra*)
- Lettuce (*aladh*
- Lapsa green
- *Patol* (*palval*)
- Rhubarb
- Spinach (*palong sag*)
- *Sag* (*palta*)
- *Sag poyee* (Malabar night shades)
- *Sag notay* (dwarf spinach)

Class II

Carbohydrate content per ounce—about 2 grammes (equivalent to about ½ teaspoonful of sugar)

- Betel leaves (*pa*)
- Beans string (*barba*)
- Brinjal (*ba gun*)
- Brussels sprouts (*chota banda kob*)
- Cabbage (*banda kobi*)
- Celery (*shalarri*)
- French beans
- Gourd bitter (*large kare a*)
- Lady's finger (*dhanrose bhindee*)
- Knol kole (*olekobi*)
- Pepper green (*ka cha lanka*)
- Plantain flower (*mocha*)
- Pumpkin red (*kumra*)
- Radish white & pink (*moola*)
- *Sag* (*dhane*)
- *Sag* (*kalmi*)
- *Sag* (*kochu*)
- *Sag* (*sarse*
- Tomato (*bilati balgun*)

Class III

Carbohydrate content per ounce—about 3 grammes (*equivalent to about* $\frac{3}{4}$ teaspoonful of sugar)

Beans broad (*seem*)
Carrot (*gajar*)
Gourd small (*uccha*)
Jack fruit unripe (*Inchar*)
Leeks (*bilati piaj*)
Mango green
Onion stalk (*piaj kali*)
Mint Sag (*pudina*)
Plantain stem (*thor*)
Turnip (*shalgam*)

Class IV

Carbohydrate content per ounce—about 4 grammes (*equivalent to about 1 teaspoonful of sugar*)

Beet (*chukander*)
Ole
Onion big and small
Parsnips

Class V

Carbohydrate *content per ounce*—about 5 *grammes* (equivalent to about $1\frac{1}{4}$ teaspoonful of sugar)

Artichoke (*hathichuk*)
Plantain green (*kaich kela*)

Class VI

Carbohydrate content per ounce—about 6 grammes (equivalent to about $1\frac{1}{2}$ teaspoonfuls of sugar)

Yam (*kachu*)
Mankachu
Peas green (*kalai suti*)
Potatoes

Classified list of fruits (arranged according to carbohydrate content)

Class I

Carbohydrate content per ounce—about 1 gramme (equivalent to about $\frac{1}{4}$ teaspoonful of sugar)

Blackberry (*kalajam*)
Coco-nut water (*dab pani*)
Cucumber (*sosha khira*)
Water melon (*turbuj*)
Pomegranates (*dalim*)

Class II

Carbohydrate content per ounce—about 2 grammes (equivalent to about $\frac{1}{2}$ teaspoonful of sugar))

- Grap fru t
- Gua a *(pea a desi)*
- L cl ee *(l cl)*
- Loquet *(okel)*
- Mel n *(foo ee)*
- Mu k n elo *kl a b ja)*
- l al n ra f u t *Tal l a*
- Plu n red ar ct *koo*
- P ebe r *go abja*
- Stra berr

Class III

Carbohydrate content per ounce—about 3 grammes (equivalent to about $\frac{3}{4}$ teaspoonful of sugar)

- Le non *(pali eb)*
- Papaya (or l nar)
- P tel e
- P neapple *a a a*
- Plu n *k o*
- l umelo *batab eb)*

Class IV

Carbohydrate content per ounce—about 4 grammes (equivalent to about 1 teaspoonful of sugar)

- Apple (ord nary)
- Cocoanut kernel *(arkel)*
- C o eberry *(lepa l*
- G a a *(pea a ka l)*
- L e *(sa bati r eb*
- M ngo *(De l)*
- P pa a be t Ranel
- Pear *naspati)*
- Po egranates *(be la a*

Class V

Carbohydrate content per ounce—about 5 grammes (equivalent to about $1\frac{1}{4}$ teaspoonful of sugar)

- An la *(a lok)*
- B el
- Bana a *(chat kela)*
- B ana *(cl a pa kela)*
- I s
- Grape wl e 4 g)
- Gr pes Bla k ar et
- M n *(La , a an l* Bon l a)
- W o apple *(ka et bael*

Class VI

- Banana (*Si cap ri kela*
- Bull ck l eart *a a)*
- J ck fru t *ka tal)*
- Water cl e tnut *paniphal)*
- Sugar-cane

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